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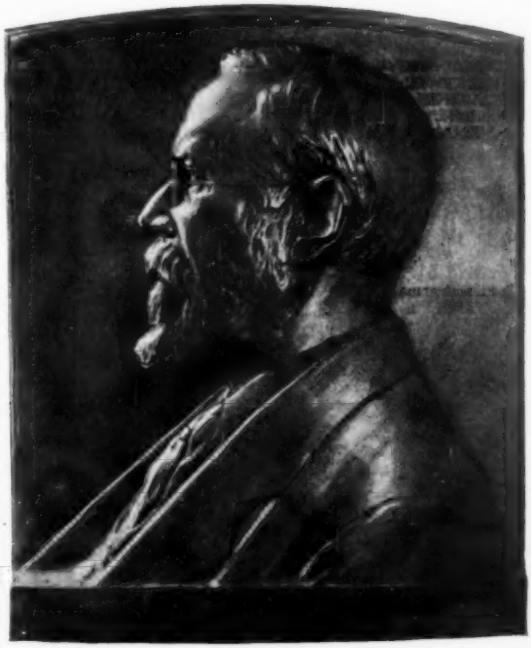

JOHN BERG

In Memoriam

JOHN WILHELM BERG was born in Stockholm on March 2nd, 1851, and died in that City on August 21st, 1931. He was a lecturer on surgery and supernumerary professor of anatomy at the Royal Caroline Institute from 1881 to 1885, professor of surgery from 1885 to 1916, and director of the Serafimer Hospital from 1893 to 1916.

For a whole generation JOHN BERG was one of the leaders in Swedish medical science and was honoured with many distinctions both at home

and abroad. Surgical science occupied the greater part of his thoughts and heart and action, and he gained his foremost successes as a teacher of surgery and as a pioneer and organiser of surgical clinics in Sweden. But laudatory mention of his name has also been made in the annals of Swedish radiology. It is largely due to JOHN BERG that Sweden has been fortunate enough in utilising more rapidly and on a larger scale than most other countries the possibilities of radiology in the sphere of medicine. He not only grasped more quickly than the majority of his generation the importance of radiology for diagnostic and therapeutic purposes, but he also understood at an early stage that radiology could not sufficiently develop and become perfectly useful except as an independent science, with its own institutions.

While in many countries the chiefs of the large surgical clinics kept back radiology, BERG himself took the initiative for important practical steps and measures for its development and improvement in Sweden. As director of the University Hospital of the Caroline Institute, to wit the Serafimer Hospital, he brought together, in the year 1908, the entire Röntgen work of the hospital into a single central teaching institute, and he himself donated the Röntgen instruments for this institute. He realised at an early date that it was impossible for the surgical clinics to undertake the radiological treatment of the cancer patients and the further development and improvement of radiotherapy, but that for that purpose there were urgently needed specially equipped radiotherapeutical clinics. At a time when very few surgeons entertained any hope for the future of radium treatment, he, in the year 1909, took the initiative for establishing the Radium Hemmet, which was opened on the 1st July, 1910. BERG himself and a few of his friends donated anonymously the fairly large sum required to fit up this clinic for radio-therapy in malignant tumours and its equipment with radium and Röntgen instruments. In the year 1911 the Swedish Cancer Society whose chairman BERG was from 1910 to 1926, took over the Radium Hemmet to which BERG devoted the utmost care.

In the year 1915 BERG, together with the then Rector of the Caroline Institute, Professor K. A. H. MÖRNER, suggested the founding of a personal professorial chair in medical radiology at the Caroline Institute, which was granted by the 1916 Riksdag and in the year 1927 was converted into an ordinary chair. This letter drawn up by BERG is a historical document which it would be well worth while to publish in those parts which concern the importance and need of development of radiology.

Right up to his death BERG devoted the keenest interest to radiology. To this testifies, inter alia, the fund bequeathed by him to the Swedish Society for Medical Radiology. In earlier years BERG not infrequently

attended the meetings of the Society. As late as last year we had the pleasure of seeing his stately figure and well beloved presence at one of our meetings, and he was delighted at the progress made by our science. He was an honorary member of the Swedish Society for Medical Radiology and of the Nordic Society for Medical Radiology.

On BERG's 70th birthday the Swedish Radiologists commemorated his work by a bronze plaquette which is reproduced here. It bears the inscription: »A master of surgery, he gave a foresighted and powerful support to young radiology.»

Gösta Forssell.

FROM MEMORIAL HOSPITAL. NEW YORK CITY

IRRADIATION OF MAMMARY CANCER WITH SPECIAL REFERENCE TO MEASURED TISSUE DOSAGE

AN EVOLUTION TOWARD AN IDEAL METHOD

by

Burton J. Lee M.D. and *George T. Pack*, M.D.

The leading clinics of Europe and America show a fair uniformity in the percentage of survivals for five years without disease following radical mastectomy for mammary cancer. Although the operation has been standardized for four decades, this figure of satisfactory end-results has remained practically unchanged (35 %), and further improvements in operative technic do not promise decided betterment. With the advent of radiation as a means of therapy for cancer, it seemed logical for surgeons to turn to these physical agents for additional aid in treating cancer of the breast. Experience with methods of irradiation for more than a decade has forced the conviction that surgery alone cannot cope adequately with the problem of mammary cancer.

Roentgen-rays or radium applied at a distance from the breast have been employed at the Memorial Hospital for more than twelve years preliminary to and following radical surgery.

Up to 1920, the only roentgen-ray machines in use at this institute were those of the so-called low voltage type. The set-up for delivering the dose was as follows: A peak voltage varying between 120 and 155 K.V., 5 milliampères of current, 2 to 4 millimeters of aluminium filter, a focal distance of 8 to 8¾ inches and a treatment time of 3 to 6 minutes. Later the time was lengthened to 7 or 8 minutes, the target-skin distance increased to 9 to 10 inches, but the number of aluminium filters was unchanged. Then, in 1921, the set-up included a peak voltage of 140 K.V., 4 milliampères of current, a filter of 4 millimeters of aluminium, a target-skin distance of 12 inches, an exposure of 15 minutes and an average portal of approximately 300 square centimeters. In 1922, with the same

[1] Submitted for publication Aug. 3rd. 1931.

peak voltage of 140 K.V., using four milliampères of current, five millimeters of aluminium filter, and a portal of entry of the same size, the target-skin distance was increased to 15 inches and the time to 25 minutes. This set-up is still in use, especially for post-operative x-ray treatment over the lower portions of the anterior and lateral chest area.

All pre-operative x-ray treatments have been given for several years past, by high voltage machines with the following factors, 200 K.V., 30 milliampères, 50 centimeters target-skin distance, and a filter of 0.5 mm. copper and 2.5 mm. aluminium.

The early »pack» for external radium therapy was constructed with a radiating area of 70 square centimeters, and a filter of 0.5 mm. of silver and 1 mm. of brass, which is the filtration equivalent of 2 mm. of brass. The radium pack carried an amount of emanation varying from 1,200 to 2,500 millicuries and was placed at a distance of 6 centimeters from the skin for an average dosage of 12,000 millicurie hours. This applicator has been largely supplanted during the past four years by the present radium element pack, which contains four grams of radium. The radium-skin distance is 6 centimeters. The filter is 0.3 mm. platinum and 1.7 mm. of brass. The average dose for therapeutic purpose is 16,000 milligram hours.

The usual breast cycle by high voltage x-ray is given through a portal 15 by 15 cm. and consists of four exposures — namely: 1. Supra and infraclavicular regions; 2. Axilla through the upper lateral aspect of the chest; 3. The breast and adjacent environment anteriorly; 4. The breast and chest wall laterally. By this method of cross-firing the breast, the dose to the tumor and its immediate environment is almost doubled. When the radium element pack is employed there have been three areas treated; namely, the breast, the axilla and the supraclavicular region. If the breast is of sufficient size and the location of the tumor is suitable, the breast has been cross-fired from two directions by the radium pack. Whatever the physical agent used, it will be noted that the supraclavicular treatment augments the amount of radiation to the apex of the axilla.

Pre-Operative External Irradiation

The basis for the use of pre-operative external irradiation depends partly upon clinical experience and partly upon histological evidence. We have had ample demonstration that many cases of mammary cancer show a partial regression after external irradiation within a few days up to a few weeks. This diminution in size is the rule rather than the exception. Tumors become better defined and in some of our inoperable cases definite mobility has been obtained where formerly fixation

to deeper parts had been present. In general, the more highly malignant the tumor the greater the degree of radiosensitivity and the more extensive are its clinical evidences of regression. In some instances complete disappearance of the tumor has occurred following external irradiation. In this manner irradiation may serve as a therapeutic test of the malignancy of a carcinoma. One does not obtain this regression with such radioresistant tumors as the scirrhous and diffuse duct carcinomas of the breast.

External irradiation followed by surgery has been the usual treatment for primary operable mammary cancer for many years, at this institution. The percentage of survivals for five years without evidence of cancer is only about five percent better than by surgery alone.

The amount of radiant energy reaching the depth of these breast tumors from external sources of radiation has always been insufficient to produce a lethal effect. The physical measurement of a dosage delivered by these methods reveals why external irradiation alone can induce only growth restraint without sterilization of these carcinomas.

Post-Operative External Irradiation

A routine cycle of x-irradiation has been given three or four weeks following the operation. By this time the wound has healed and the patient has recovered sufficiently to undergo treatment without much distress. In our hands, the results have been better when postoperative irradiation has followed surgery, than with surgery alone. In general, surgeons have been more willing to submit their patients to post-operative irradiation than to pre-operative treatment in the belief that the likelihood of local recurrence in the operative field was thereby diminished. A continuous follow-up upon these patients month by month may reveal evidences of recurrence, to which appropriate treatment may be applied. Sufficient data are at hand to prove that post-operative irradiation diminishes the liability to recurrence and prolongs considerably the life of the patient. Yet there are three possible arguments against the procedure; the dosage delivered is insufficient to destroy any viable carcinoma left in the operative field, although it may be instrumental in inhibiting the growth of such cells by enveloping them in dense scar tissue; if a recurrence does appear after such irradiation, the intensity of the subsequent treatments must be lessened because of the diminished tolerance of the skin; carcinomas which have recurred in the face of irradiation have probably an increased radioresistance. The post-operative x-ray treatments are usually given twice a week, with exposure of the same areas used in the preoperative cycle. The dose employed for the supraclavicular and axillary spaces is relatively somewhat heavier than that over the anterior chest wall. The breast, having been removed, only a super-

ficial dose is necessary over the lower half of the operative field whereas for the axilla and supraclavicular regions, a relatively greater depth dose seems indicated and this is particularly true whenever axillary metastases are revealed at operation. For this reason, high voltage x-ray treatment is given to the axilla and supraclavicular space, and low voltage x-ray treatment to the mammary site on the anterior chest wall.

Physical Advantages of Mammary Cancer for Treatment by Irradiation

Carcinoma situated in the breast has certain physical advantages for treatment by irradiation. The mammary gland is superficial enough that any tumor in its depth may receive a considerable percentage of the energy from external sources of radiation. The accessibility of the breast permits reasonably correct measurement of the tumor, accurate estimation of dosage and proper implantation of radioactive foci. The reactionary phenomena following irradiation of the breast are of little moment and are seldom complicated by sloughing and infection, which are frequently present in tumors of the respiratory, genito-urinary and alimentary canals. The loss of mammary function is relatively unimportant to a patient with carcinoma of the breast, inasmuch as their average age is slightly over fifty years.

Opposed to these advantages are certain undeniable handicaps to successful irradiation of cancer of the breast. The majority of mammary cancers are relatively radioresistant. The thick fat envelope of the breast is an extremely poor reactive tissue bed, which contributes little in the way of productive inflammation and fibrosis toward the destruction of carcinoma by irradiation. The delicate skin of the breast will not tolerate much external irradiation. Many breast cancers have metastasized widely before any treatment has been instituted; in such an event it is just as important (although more difficult) to destroy the metastatic carcinoma as it is the primary lesion.

Interstitial Irradiation

We soon appreciated that an efficient devitalizing dose could not be delivered by external irradiation alone and therefore turned to the use of interstitial irradiation in order to deliver a more effective dose to the tumor and gland bearing regions. The method of interstitial irradiation at the Memorial Hospital in the treatment of mammary cancer has gone through a considerable evolution during the past twelve years.

Unfiltered Interstitial Irradiation

At first, radon was collected in tiny glass capillary tubes, which were subdivided into short segments called »bare glass radon seeds». For the

treatment of carcinoma of the breast, the glass-filtered radon implants were inserted interstitially to deliver a dosage of approximately one millicurie for each cubic centimeter of tumor tissue. The general tendency was to give repeated treatments in small doses, but the treatment of small tumors was frequently carried out in one sitting. The glass wall of the seed filtered out the alpha rays and some of the soft beta rays, but sufficient of the latter escaped to exert a caustic action on the tissue surrounding the seeds. Enveloping each glass seed was a sphere of coagulation necrosis which in turn was surrounded by an outer zone of non-viable but recognizable carcinoma. The beta rays were stopped by the carcinoma but the more penetrating gamma rays extended farther peripherally to sterilize a still larger sphere of tissue. These »bare glass seeds» produced much more necrosis than occurs from gold-filtered implants. The sequence of events in the irradiated breast was carbonization, liquefaction necrosis and dense fibrosis. Dr. EWING, who studied these histological changes with the microscope, has long maintained that the glass-filtered radon seeds are superior to gold seeds for interstitial irradiation of the breast. We have thus far preferred to use the gold-filtered radon seeds because it affords more selective gamma radiation and less actual necrosis.

Radium Puncture by Platinum-Filtered Needles

In 1920 we first employed hollow, radon-containing needles for interstitial irradiation of mammary cancer. Each needle had a steel shank eight to ten centimeters long to which was attached a platinum point four centimeters long, with a wall 0.4 millimeters thick. Into the platinum tip thirty to sixty millicuries of radium emanation were introduced and sealed by paraffin. The needles were sterilized by immersion in alcohol. The longitudinal and transverse diameters of the tumor having been determined by caliper measurement and the average thickness estimated, the cubic contents were calculated. At first, the dosage used was 25 millicurie hours per cubic centimeter; later the dosage was increased to 50 millicurie hours per cubic centimeter of tissue. Under novocaine anesthesia the needles were passed through the skin and into the tumor along peripheral transverse lines endeavoring to place them equidistant from the anterior and posterior surfaces. Now that we have available more accurate data concerning cancericidal doses of radium, we can appreciate in retrospect, the remarkably good results obtained with these radon needles in consideration of the small dose delivered. One serious objection to their usage was the attendant trauma. The needles were also directed subpectorally toward the axillary apex and downward into the axilla from the infraclavicular region.

In reviewing the results obtained by the use of external irradiation combined with interstitial irradiation with glass radon seeds or platinum filtered radon needles, we realize that the failures in large part might be attributed to our ignorance of the lethal dose for mammary cancer.

The Determination of the Lethal Dose of Irradiation for Mammary Cancer

In 1927 Dr. QUIMBY and one of us (B. J. L.) first conducted a clinical experiment to determine the results that might be obtained in the treatment of mammary cancer, using measured tissue doses of external irradiation alone. The tumors were accurately measured and the minimal dose received by the tumor was calculated. In this study high voltage x-rays were employed. Unfortunately in the fifty patients so treated histological verification of cancer was obtained by biopsy or operation in twenty-two only. The results were disappointing in the effort to control mammary cancer by external irradiation alone, which confirmed our previous impression concerning its efficacy. It was evident that supplementary interstitial irradiation would be necessary.

Gold radon seeds had previously been devised by Dr. FAILLA and were in general use throughout the hospital. We believed the implantation of gold radon seeds would furnish the supplementary irradiation needed to devitalize mammary cancer completely. It seemed opportune to conduct a clinical experiment to determine beyond question of a doubt the devitalizing dose for carcinoma of the breast. Moreover, the treatment of mammary carcinoma with measured dosage seemed to offer an accurate method of treating the disease.

In primary operable mammary cancer, the breasts were removed together with axillary contents and muscles at variable intervals after the completion of irradiation, and were subjected to careful microscopic study of multiple and whole breast sections. This material afforded opportunity to judge the efficacy of the various methods of irradiation, to estimate the probable sterilizing dose for mammary cancer, to determine the radiosensitivity of breast cancers in terms of biological units of measurement and frequently to study the various tissue changes produced by the different methods of irradiation.

Palliative mastectomy in certain of the primary inoperable cases would also furnish additional data. It seemed desirable, also to determine whether or not this technic could be made use of to the advantage of the patient as a routine pre-operative measure. The study which has been carried out might also demonstrate the limitations of the method as well as contraindications to its use, if there were any.

The Physical Principles Underlying the Estimation of Tissue Dosage[1]

In studying the response of any tumor to irradiation, we must realize that any changes so produced are proportionate in some degree to the actual amount of radiant energy delivered to that tumor. In the case of external irradiation, the dose at the source or at the skin surface is not the correct notation for the tumor dosage, because the amount delivered at a point within the breast varies markedly with the depth of the tumor below the skin, acccording to the operation of the inverse square law.

At this institution, the amount of irradiation delivered at any given point in the tissue is called the tissue dose at that point. (30, 31). The tissue dose of a given volume of tumor is considered as of that point within it, which receives the smallest quantity of energy. The unit of quantity of radiation employed at the Memorial Hospital, and in terms of which all tissue doses are expressed, is the threshold erythema dose; this is the amount of radiation, which after a single application will produce in 80 % of all cases, a faint bronzing or reddening of the skin in three weeks, and in the other 20 % will produce no visible effect.

Table No. 1

Depth	X-rays 200 kv. 0.5 mm. Cu, 50 cm.	X-rays 175 kv. 0.5 mm. Cu, 30 cm.	Radium element Pack at 6 cm.	Radon tray at 3 cm.
0	100	100	100	100
1	99	92	75	62
3	85	73	51	27
5	68	53	36	14
7	52	36	25	8
10	33	20	16	4
12	25	15	12	—
15	17	10	9	—

By means of physical experiments the percentage of the amount of radiation falling on the skin which arrives at any depth within the underlying tissue has been determined. By reference to this table (No. 1) of depth dosage, we can determine at once the tissue dose of external irradiation if we know the depth of the tumor below each portal and the amount of radiation falling on the skin at each portal, in terms of the threshold erythema. (S. E. D.) It can be seen that in very few cases external irra-

[1] These physical principles were established by the experimentation of Dr. QUIMBY in the Physical Laboratory.

Table No. 2. Millicuries in Gold Seeds Required to Deliver Specified Doses to Masses of Various Diameters

Skin erythema doses	Diameter of mass — Centimeters											
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0
	Number of millicuries											
1	0.2	0.5	0.8	1.5	2.0	2.4	2.9	3.4	4.0	5.4	7.0	9.0
2	0.4	1.0	1.6	3.0	4.0	4.8	5.8	6.8	8.0	11.0	14.0	18.0
3	0.6	1.5	2.4	4.5	6.0	7.2	8.7	10.0	12.0	16.0	21.0	27.0
4	0.8	2.0	3.2	6.0	8.0	9.6	12.0	14.0	16.0	22.0	28.0	36.0
5	1.0	2.5	4.0	7.5	10.0	12.0	14.0	17.0	20.0	27.0	35.0	45.0
6	1.2	3.0	4.8	9.0	12.0	14.0	17.0	20.0	24.0	32.0	42.0	54.0
7	1.4	3.5	5.6	10.0	14.0	17.0	20.0	24.0	28.0	38.0	49.0	63.0
8	1.6	4.0	6.4	12.0	16.0	19.0	23.0	27.0	32.0	43.0	56.0	72.0
9	1.8	4.5	7.2	14.0	18.0	22.0	26.0	31.0	36.0	49.0	63.0	81.0
10	2.0	5.0	8.0	15.0	20.0	24.0	29.9	34.0	40.0	54.0	70.0	90.0
11	2.2	5.5	8.8	17.0	22.0	26.0	32.0	37.0	44.0	59.0	77.0	99.0
12	2.4	6.0	9.6	18.0	24.0	29.0	35.0	41.0	48.0	65.0	84.0	108.0
13	2.6	6.5	10.0	20.0	26.0	31.0	38.0	44.0	52.0	70.0	91.0	117.0
14	2.8	7.0	12.0	21.0	28.0	34.0	41.0	48.0	56.0	76.0	98.0	126.0
15	3.0	7.5	13.0	23.0	30.0	36.0	44.0	51.0	60.0	81.0	105.0	135 0

diation cannot deliver more than one to one and a half S. E. D. into the tumor at its deepest part.

The calculation of the dose delivered by interstitial irradiation is more difficult and less exact, but the dose is never less than the calculated dose, and is usually more. The interstitial sources of radiation used in this experiment were gold filtered radon seeds, 4 millimeters long, 0.3 millimeters in wall thickness and with one to three millicuries content of radon. Experiments in the physical department permit the determination of the percentage of a threshold erythema delivered at any distance from any gold seed. It is self evident that every point within the cancer should receive a certain minimum dose, and it is this dose which should be calculated. Other portions of the tumor may receive larger doses than the calculated one.

It is the practice to consider for each tumor that sphere of tissue which will just encompass it. In the case of elongated tumors, the computation of dosage is based on two or more contiguous spheres which enclose the tumor; an adaptation of this principle may be used for any tumors of irregular shape. If the radon is concentrated in the center of the sphere or distributed uniformly within the inner half of the sphere, the mini-

mum dose expressed in the calculation will uniformly be the amount of radiation arriving at the periphery of such a sphere. For instance, one millicurie of radon placed at the center of a 3 centimeter sphere would deliver fifty percent of an erythema dose on the periphery of the tumor, and ten millicuries would be necessary to deliver ten times this much or five hundred percent (5 S. E. D.).

For convenience in calculation, Dr. QUIMBY has prepared a table of doses for different quantities of radon in spheres of different diameters.

The Computation of Total Dose by Combined External and Interstitial Irradiation

With the patient in the recumbent posture the transverse and vertical contours of the involved breast at the level of the tumor are taken by adjustments of flexible lead tapes with later tracings on paper for permanent record. The breast tumor is measured in its three dimensions by

Patient. A. S., widow, act. 58, para 5.

Tumor. Left breast above nipple = 4 × 5½ cms.

Problem. To deliver 700 % erythema dose into tumor.

Ext. Irradiation. High voltage X-rays. Shoulder.

1. 85 % erythema dose.
2. 85 % erythema dose.
3. $\frac{64\ \%\ \text{erythema dose}}{234\ \%\ \text{erythema dose}}$ = Total dosage.

700 — 234 = 466 % erythema dose to be given by supplementary interstitial irradiation.

Tumor 5½ cms. in size would require 43 millicuries of radon in gold seeds.

Gave 43.43 millicuries in 15 gold seeds into breast tumor.

Gave 10.4 millicuries in 4 gold seeds in axillary nodes.

Gave 5.2 millicuries in 2 gold seeds in infraclavicular node.

Axilla and Supra-clavicular space received supplementary X-irradiation.

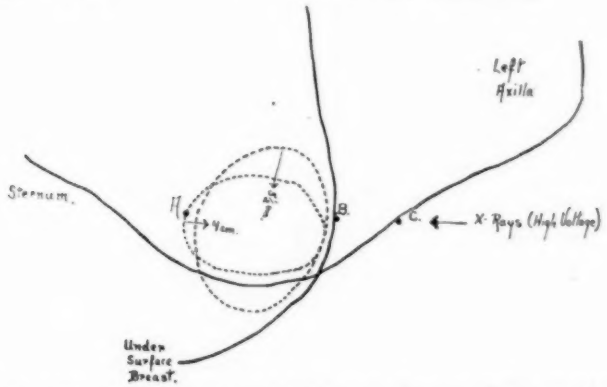

Fig. 1. Outline graph of contours of breast to illustrate the computation of total tissue dose in mammary cancer from combined external irradiation. The patient was an aged emaciated negress with a large carcinoma in a small breast. The diagnosis was verified by aspiration biopsy. Because of the contiguity of tumor and chest wall and the smallness of the breast, a tissue dosage of only 7 S.E.D. (700 %) was prescribed. The carcinoma disappeared completely and did not recur.

calipers, calibrated in centimeters. The exact location and size of the tumor are recorded on the traced contour of the breast, care being taken to show the exact depth below the level of the skin. This graphic record is used for estimating the amount of radiation delivered from external sources to the most remote portion of the tumor.

External irradiation always precedes the implantation of gold radon seeds because it should make the later interstitial introduction a less hazardous procedure, chiefly for the following reasons: 1. It produces some degree of tumor devitalization; 2. It ultimately impairs the blood supply to the tumor by a productive endarteritis which may even result in vascular occlusion. The tissue dosage delivered to the tumor by external irradiation is computed, and this amount is subtracted from the total dose which has been prescribed. The remaining amount and major portion of the dose to be given is delivered by gold radon seeds placed interstitially.

The Technic of Interstitial Irradiation

Interstitial irradiation as employed in this series of cases consisted in the distribution of tiny non-removable, gold-filtered radon seeds within the substance of the tumor, in the breast tissues surrounding the tumor and in the corresponding axilla. In contrast to the more radical surgical measures, there is no mortality consequent to the introduction of these gold radon seeds; patients with serious cardiac ailments, diabetes, pulmonary tuberculosis, etc., have been treated safely by this method. The possible menace of dissemination of the disease by the method of interstitial irradiation has been considered. Our survey of the patients treated thus far has revealed no instance of rapid metastasis which could be interpreted as caused by an implant of tumor tissue into the blood or lymph stream, and a sufficient time has elapsed to make our observations on this point reasonably trustworthy.

Preparatory to inserting the gold radon seeds into the breast, the entire area is prepared carefully as for a major surgical operation. The proper use of antisepsis and sterile drapery is essential in order to avoid infection of the cancer. In only one instance in which gold radon implants were used did the complication of infection occur; the resultant breast abscess was a considerable handicap in the subsequent management of this case and greatly delayed convalescence. Nitrous oxide anesthesia is used for the very brief time required for the insertion of the seeds.

Each gold radon seed is sterilized in alcohol and placed within a sterile long needle trocar carrying a minute metal plunger for the purpose of dislodging the seed into the depths of the tumor. These needles

have sharpened points and are only 1.3 mm. in diameter in order to cause the least possible trauma. Caution should be exercised that the tubes or seeds are not placed near the skin; otherwise they may cause ulceration. Also one should be careful to avoid placing the seeds against a rib or costo-chondral junction, because of the possibility of injuring the periosteum or cartilage. The seeds are placed as nearly as possible one-half of the distance to the center along the various radii of a sphere of tissue which just encompasses the tumor, taking care to place them at all levels. More recently the immediate environment of the tumor has also received interstitial irradiation by gold seed implants.

The Proper Tissue Dosage of Irradiation

A marked variation in dosage was used in the series under discussion, but one should bear in mind that a clinical study was being carried on without preceding data to guide one. In handling the smaller tumors it is possible to give a surprisingly large dose without undue damage to normal surrounding structures. When, however, one is attempting to treat adequately a large mammary cancer by interstitial irradiation the problem becomes more complex and difficult. With some of the larger tumors it is practically impossible to devitalize completely the tumor by interstitial radon without causing serious damage to the skin, subcutaneous tissue and subjacent structures. In a considerable number of cases large vesicles formed in the skin overlying the breast, and the ensuing ulcer did not heal until several weeks later. The tumors have been categorically divided according to their size, into three groups, in order that one may visualize better the type of tumor being treated, and have a clearer picture of the amount of radon implanted. Tumors 3 cm. or less in diameter have been designated as small, up to 6 cm. in diameter, medium, and above these dimensions, large.

The dosage employed in the small tumors varied from 760 % to 1,900 % S. E. D., in five instances varying from 1,200 % to 1,500 % S. E. D. In the previous communication the conclusion was reached, that a dosage of 1,200 % S. E. D. was necessary to destroy a radioresistant mammary cancer. The smallest doses employed in interstitially irradiated tumors of 3 cm. or less were 760 %, 900 % and 1,000 % S. E. D., and in no instance did we find that the tumor was completely devitalized. Upon the other hand, when a dosage of 1,200 % S. E. D. or more, was used, devitalization of the tumor was accomplished, so that one may consider this an effective devitalizing dose for the smaller tumors, and a larger dose unnecessary. As a matter of practice, when the tumor is 3 cm or less in diameter, the dosage is given as if the tumor were 5 cm. in

diameter, thereby radiating adequately the all important growing edge of the cancer.

In tumors between 3 to 6 cm. in diameter the dosage employed varied from 650 % to 2,400 % S. E. D. One case in this group which received a dosage of 940 % S. E. D., for a tumor $5^1/_2 \times 3$ cm. showed complete destruction of the tumor which was a cellular carcinoma and, therefore, probably highly radiosensitive. Another tumor of radioresistant type received 1,265 % S. E. D., and did not show complete tumor destruction. In general, when a dosage of 1,200 % S. E. D. was employed, complete devitalization was accomplished, but we believe that 1,300 % S. E. D., may be required to destroy completely the most radioresistant tumor of these dimensions. This method of radon implantation appears, therefore, equally applicable to tumors 3 to 6 cm. in diameter.

Larger tumors are unsuitable for the method.

In a few instances wherein very radiosensitive carcinomas disappeared completely after external irradiation alone, we have not been content with this immediate result, for in many earlier cases we found that the tumor had not been completely devitalized. We have given, therefore, supplementary doses of interstitial irradiation based on the original measurements of the tumor. Although mammary cancers may vary in radiosensitivity, we believe the safest procedure is to treat all with the same sufficient dose, because radiosensitivity cannot always be determined before operation and the same tumor may contain radioresistant and radiosensitive portions.

Tolerance of the Mammary Gland to Large Doses of Irradiation

The mammary gland will tolerate safely an enormous dose of interstitial irradiation. The first time forty millicuries were introduced into the breast, we were somewhat fearful of the consequences, but no untoward effects were evident. The largest dose of interstitial irradiation given to any patient in this series was 133 millicuries. This quantity, delivering an S. E. D. of 2,070 percent, was implanted into a tumor measuring $6^1/_2 \times 5$ cm. and located in a large adipose, pendulous breast. An intense reaction followed but the skin healed perfectly. Radical mastectomy was delayed until three and a half months had passed. Histological examination revealed complete radium necrosis of a carcinoma simplex. The wound healed well. There is no clinical evidence of cancer at the present time, one year and six months after irradiation.

Larger breasts tolerate larger doses; consequently carcinomas of considerable size in large breasts can be given more vigorous interstitial irradiation than carcinomas of the same size in smaller breasts.

Irradiation of the Axilla with External Irradiation and Gold Radon Implants

The axilla is irradiated whether or not axillary nodes are palpable, for we have shown that there is a possibility of error of 17 percent in determining the presence or absence of involved axillary nodes. The axilla is irradiated by preoperative x-rays or radium element pack followed by interstitial gold-filtered radon distributed along the gland-bearing areas. In general we have found the management of axillary nodes one of the big problems in the treatment of mammary cancer by radiation.

The axillary nodes are quite variable in their distribution and cannot be accurately localized at fixed anatomical points. EWING has said: »Unlike cervical lymph nodes, axillary nodes may lack complete capsules and are readily traversed by tumor cells.» The dispersion of active carcinoma cells in the axillary fat seriously hinders the eradication of cancer in this location, because these cells divide rapidly in spite of heavy external irradiation. As long as the cancer cells remain within the node, external irradiation has perceptible influence because of the pressure atrophy, vascular occlusion with ischemia, and strangulation. The difficulties attendant on depth dosage estimation from external radiation are several. The axilla is a truncated cone or rather an equilateral four-sided pyramid which varies in shape and depth in different individuals. When multiple metastases to several axillary nodes have occurred, the correct estimation of tissue dosage for these nodes is impossible. When one or two quite large, movable nodes are present, the tissue dose can be calculated and readily delivered.

The gold seeds are implanted in all cases without surgical exposure of the axilla, the technic and time of implantation are the same as for the breast. Rows of gold seeds are placed along the lymphatic trunks leading to the axilla and along the important intermuscular trunks. The arm being abducted to a right angle, the needle points are guided into the axilla by careful palpation, while the left hand of the surgeon presses against the inner aspect of the arm, to displace outward the axillary vessels and accompanying brachial plexus. In general, we endeavor to irradiate the entire axilla, distributing the seeds from a point just below the apex to the base. Seeds are also implanted into the regions occupied by the following groups of nodes: subpectoral, intermuscular, subclavicular and the node over the insertion of the latissimus dorsi muscle. The subclavicular groups are particularly important because they constitute immediate relay stations prior to involvement of the supraclavicular nodes; the needles are inserted into this region by a row of transcutaneous punctures below and parallel to the outer half of the clavicle.

The doses introduced into the axilla varied from 16 to 39 millicuries, the average dosage being from 24 to 28 millicuries. The radon content of these seeds was 2 to 3 millicuries.

Following the implantation, the extremity is retained in an abducted position for four days, for if adduction is permitted, the inner surface of the arm and adjacent brachial plexus will come into too close a proximity to the source of radiation.

Ten of the patients subjected to radical amputation, who had received gold radon implants in the axilla, furnished pathological material to determine the adequacy of this form of irradiation for metastases to axillary nodes. In one-half of the cases viable tumor tissue could be recognized in the nodes removed. In two other instances, invaded axillary nodes showed marked atrophy of tumor cells suggesting that a fairly complete devitalization had been accomplished. In three of the patients no report was made on the condition of the axillary nodes, histologically. This group is too small upon which to base conclusions, but the findings in the laboratory, coupled with our appreciation of the difficulty of adequate and satisfactory implantation, indicate that our irradiation was probably ineffective in this region.

In three of the primary operable cases subjected to local mastectomy only, interstitial irradiation was used in the treatment of the axilla. In the six patients in whom surgery was withheld, three received interstitial irradiation into the axilla. Satisfactory regression of the axillary disease followed, but no dissection of the space was carried out, and, therefore, no pathological data could be obtained.

In one instance in which 21 millicuries were introduced into the axilla using seven gold seeds, a disturbing neuritis developed along the course of the brachial plexus. Pain appeared two weeks after the introduction and an increasing disability of the arm developed. Operation was postponed for three months and then radical amputation was performed in the hope of relieving scar tissue pressure upon the plexus. At operation, three seeds were found in close proximity to the axillary vein and adjacent plexus In spite of the scar tissue present, a satisfactory dissection was made and the wound healed by primary union. Although this operation was performed more than nine months ago, a neuritis still persists with some considerable degree of disability. Neuritis is caused, undoubtedly, by the implantation of seeds at the apex of the axilla, bringing them too close to the plexus, and can be prevented if this step is omitted. Moreover, if the disease has invaded the very summit of the axilla, it is incurable by any known method.

The Pathologic Changes Produced by Irradiation in Carcinoma of the Breast

In an earlier article, soon to be published in The Archives of Surgery, we attempted an estimation of the radiosensitivity of mammary carci-

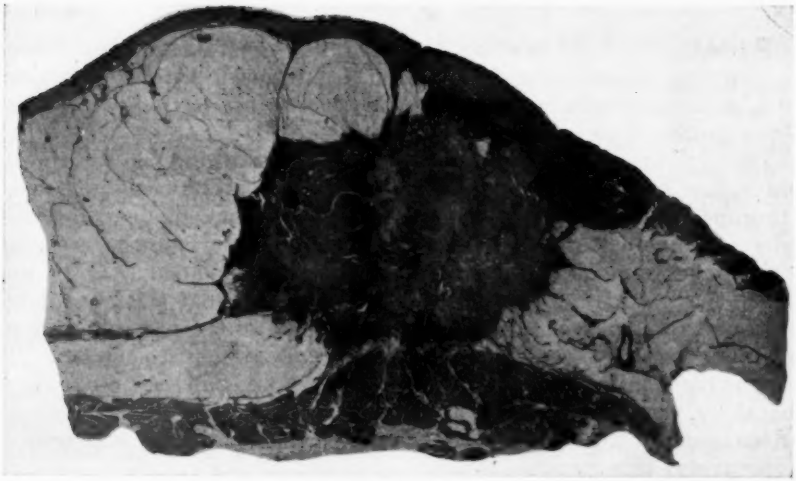

Fig. 2. Whole section through entire breast to show a bulky adenocarcinoma. No preoperative radiation therapy had been given. Similar preparations were used to study the tissue changes induced in mammary cancer by measured tissue doses of irradiation.

Fig. 3. Whole section through breast which had been treated for a large carcinoma by combined external and interstitial irradiation. The cellular portions of the tumor are completely necrotic. No viable carcinoma can be recognized on microscopical study. The more resistant normal ducts persist in scattered foci; these ducts exhibit squamous metaplasia.

nomas and made a classification of them, based on radiosensitivity. Therefore, we shall not discuss this subject here. (25) We also considered at great length the tissue changes in mammary cancer and in normal breast tissue brought about by various forms of irradiation. We shall merely summarize these subjects here.

In tabulating the histological changes following external and interstitial irradiation, we realize that the different pathologic pictures encountered cannot be attributed entirely to the various modes of irradiation,

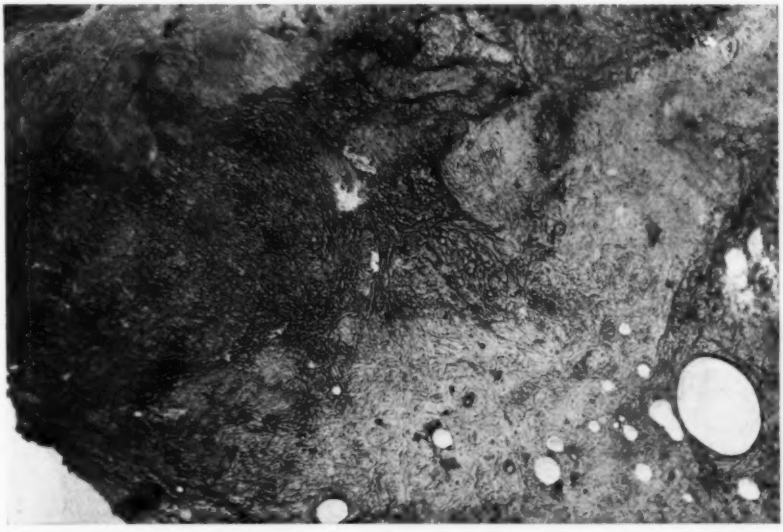

Fig. 4. Complete coagulation necrosis of carcinoma of the breast caused by interstitial irradiation. Fusion of fat cells.

but must also be influenced by the dosage used and different intensities of radiation afforded by these two methods.

The changes induced by external irradiation may be enumerated as follows: vascular changes such as productive arteritis with thrombosis and resultant infarction and massive necrosis of certain tumors (bulky-adeno-carcinomas, papillary intracystic adeno-carcinomas); calcific deposits in vessel walls; productive fibrosis and collagen swelling; hydrops and atrophic degeneration of tumor cells. The changes produced by interstitial irradiation may be enumerated as follows: Disappearance of tumor, leaving only areas of haemorrhage and necrosis (medullary carcinomas, cellular anaplastic adeno-carcinomas); deposits of calcium; acute capillary necrosis with resultant tumor destruction; hydropic swelling and ballooning

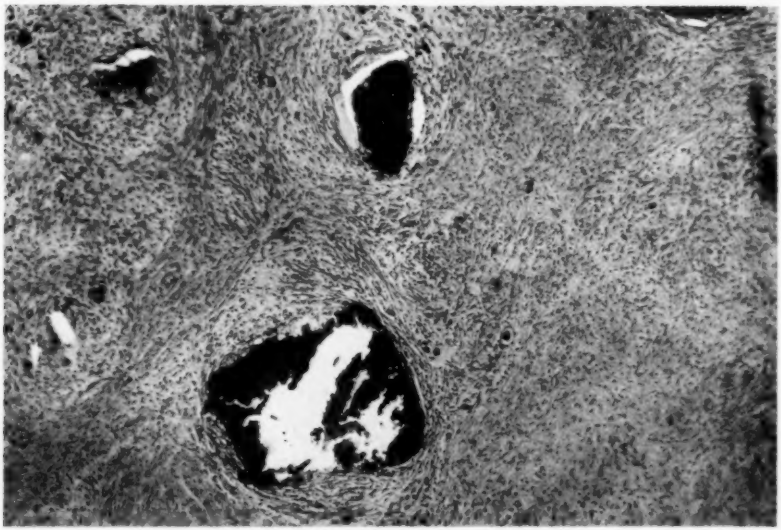

Fig. 5. Pathologic changes induced in mammary cancer by heavy external irradiation. Atrophy and disintegration of tumor cells. Atypical degenerative mitoses and giant nuclei. Deposition of calcium in regions of fat necrosis.

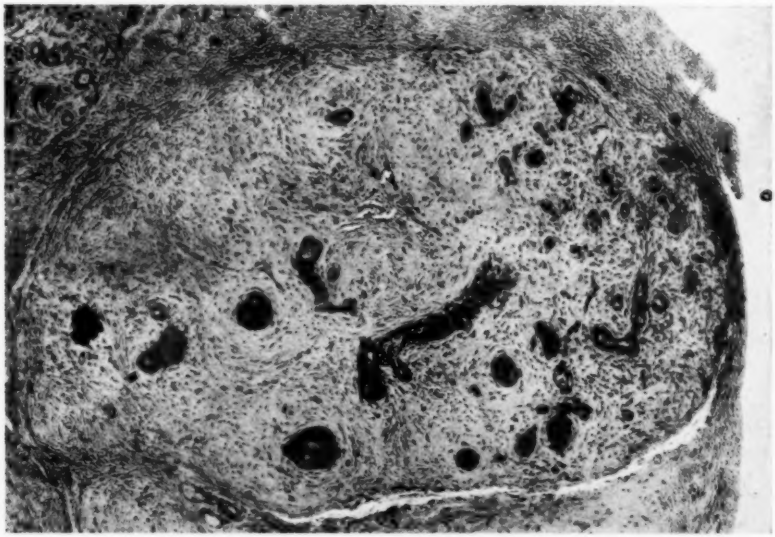

Fig. 6. Squamous metaplasia of ducts in normal breast lobule adjoining a carcinoma which had received a large dose of interstitial irradiation.

degeneration of tumor cells, giant nuclei and atypical degenerative mitoses; squamous metaplasia of tumor cells, followed by sloughing within the lumina (comedo-carcinomas, large cell duct carcinomas); collagen swelling, productive fibrosis and late atrophy of residual tumor; squamous metaplasia of ducts in normal adjacent breast lobules.[1]

An Evaluation of the Method as a Preoperative Measure

Although the major object of this research was to determine the lethal dose of radiation for mammary cancer, we desired also to prove or disprove the efficacy of this method as a preoperative measure. Experience with the patients in this series has convinced us that combined external and interstitial irradiation should not be proposed as a routine preoperative procedure in the treatment of primary operable mammary cancer, for the following reasons:

1. The inevitable pain following adequate irradiation.
2. The postponement of operation for six weeks is disturbing to the patient.
3. The added expense is also a matter of importance.

But, these advantages would be completely compensated for if the ultimate end results were better than those afforded by other methods. A tractible patient, with a small, well localized mammary tumor, with or without low axillary metastasis, is a suitable case for the use of the technic. In spite of the disadvantages attendant upon the method, one must realize that we have scarcely gone beyond the experimental stage in applying this treatment to mammary carcinoma. Devitalization of a small, well defined tumor should furnish, on theoretical grounds, a better ultimate result, and the follow-up upon these cases with the addition of others treated by the method may demonstrate its efficacy. We propose to continue the use of this preoperative technic in certain well selected patients of the type which we have indicated.

The Effect of Irradiation upon Healing of the Operative Wound

One of the important problems presenting itself for solution was the influence of the irradiation on postoperative wound healing.

The factors influential in wound healing following radical mastectomies for carcinomas of the breast which have been treated pre-operatively by irradiation, are several, namely: (a) The presence of an open infected lesion, as a source of wound contamination. This same hazard obtains in non-irradiated cases, but is of more serious import here because of the

[1] We are indebted to Dr. FRED W. STEWART for his studies on this subject.

tenacity with which infection persists in irradiated tissues. (b) The adiposity of the breast and the axilla. Wound healing in obese individuals is difficult in the best circumstances, but in irradiated fat tissue the process is even slower. (c) The size of the tumor especially in comparison with the size of the breast. (d) The amount of skin sacrificed and the consequent degree of wound tension. With the progress of time, the vascularity of irradiated skin gradually diminishes, which condition impedes wound healing. (e) The employment of external irradiation. All other conditions being equal, the tissue dosage delivered by external irradiation through the skin to the tumor, provokes far greater injury to the skin than an equivalent dosage given interstitially. (f) The use of interstitial irradiation and the total quantity of radium emanation employed as well as the limitation of the dosage of interstitial irradiation by the size of the breast. This problem has been readily solved and is dependent somewhat on the relation of the size of the tumor to that of the breast which contains it. When a bulky carcinoma occupies almost the entire breast, a lethal dose of interstitial irradiation may destroy the skin, produce ulceration, delay amputation and impair the healing of the wound. (g) The proximity of the gold radon seeds to the chest wall. If the carcinoma be situated deeply in the breast, in contact with the thoracic wall, care must be exercised in the dosage and placement of the gold radon seeds, otherwise late radiation effects, such as periosteal or perichondreal damage and tardy bone necrosis may ensure. (h) The time interval between the completion of the irradiation and the operation.

An analysis of the cases reveals that the major factors determining poor wound healing are:

1. Excessive interstitial irradiation.
2. Undue wound tension because of the sacrifice of a considerable area of skin.
3. A short time interval between the employment of interstitial irradiation and radical amputation, and this is the most important of the three.

Excessive Interstitial Irradiation

One patient in the primary operable and two in the primary inoperable group showed delayed wound healing which could be fairly attributed to an overdosage of the tumor by interstitial radon. The first of these, a primary operable patient with a tumor 5 × 4 × 3 cm. received 1,850 % S. E. D. with interstitially implanted radon. A period of eight and a half months elapsed before radical mastectomy was performed because of the presence of an extensive aggravated dermatitis. Following the operation, the dermatitis persisted and the wound did not com-

pletely close until several weeks had elapsed. Of the two cases in the primary inoperable series, the first received 1,720 % S. E. D. of interstitial radon, a period of six weeks elapsing before amputation was undertaken. The second received 2,150 % S. E. D., a period of forty-four days ensuing between interstitial irradiation and surgical intervention. Considering this long time interval between irradiation and operation in these three patients, one may safely conclude that the delayed wound healing was due to excessive interstitial irradiation.

Wound Tension

Two patients in the primary operable group who received, approximately, 1,200 % S. E. D., in whom the time interval elapsing between the implantation of gold radon seeds and radical amputation was six and seven weeks, respectively, developed considerable necrosis along the the wound edges with a subsequent low grade infection. In each instance a large amount of skin had been removed in doing the radical amputation, and although the wounds were completely closed by the use of Stewart submarine tension sutures, unwise and undue tension of the skin was evident at the termination of the operation. Excessive wound tension can, therefore, reasonably be assigned as the cause of the secondary wound healing in these two instances. A review of these cases strongly suggests that a partial wound closure, without tension, would have resulted in primary union in the sutured portions of the wound.

A Short Time Interval between Interstitial Irradiation and Surgical Intervention

Six of the primary operable patients in whom secondary wound healing was encountered, had not received an excessive dosage of interstitial radon, nor was undue wound tension a prominent feature. The dosage employed in these six instances varied between 635 % and 1,500 % S. E. D., but an interval of only three to five weeks was allowed between gold seed implantation and surgical intervention.

The following table indicates the dosage used and the time interval before operation in these six cases:

Secondary Wound Healing

1.	635 % S. E. D.	Interval	29	Days.
2.	650 % S. E. D.	»	36	»
3.	1,000 % S. E. D.	»	20	»
4.	1,000 % S. E. D.	»	27	»
5.	1,200 % S. E. D.	»	21	»
6.	1,500 % S. E. D.	»	36	»

A review of these patients has convinced us that the inflammatory reaction induced by the implanted radon had not completely subsided before surgery was undertaken. *The conclusion seems justified that a period of at least six weeks should elapse from the time of interstitial irradiation to operative interference.*

The allowance of an optimal interval diminishes the risk of infection, permits the subsidence of the inflammatory reaction in the skin of the breast, affords the necessary time for destruction of the tumor by irradiation, gives the deeper breast substance and contiguous tissues an opportunity to recover from the intense radium reaction, and thus insures uncomplicated wound healing. When the operation is done sooner, additional hemostasis is necessary because of the post-radiation hyperemia present and the fresh wound shares in the tissue destruction. On the other hand when the operation is unwisely delayed some months after massive over-irradiation, the consequent fibrosis and ischemia frequently hinder the process of repair in the wound.

Within certain limits a large dosage in the tumor may not result in unsatisfactory healing of the wound, if a long interval of time has been permitted before surgery is undertaken, as the table on the following four patients illustrates:

Primary Union — In spite of excessive dosage, but with adequate time interval

1.	1,625 % S. E. D.	Interval	42	Days.
2.	1,800 % S. E. D.	»	68	»
3.	2,060 % S. E. D.	»	70	»
4.	2,400 % S. E. D. (111 millicuries)	»	42	»

Primary wound healing will be obtained in tumors of 6 cm. or less if a dosage of 1,200 % or 1,300 % S. E. D. is employed, if no undue wound tension is permitted in the closure and if at least six weeks elapse between irradiation and surgical intervention.

Results

In our former paper a considerable number of patients were included in whom histological verification of cancer was lacking. These have been excluded from this report as well as three patients who left the clinic not to return. The use of the aspiration biopsy technic developed by MARTIN and ELLIS of the Memorial Hospital Staff, and recently the employment of the Hoffman Punch in tumors of firmer texture, has furnished adequate material for histological diagnosis. These methods are of special value in proving the presence of cancer in cases selected

for irradiation alone and such proof should be obtained if end-results are to be considered trustworthy.

The total number under consideration is forty-one, thirty of whom were primary operable and eleven primary inoperable cases. The shortest time that any individual has been under observation is one year and one month, the longest, two years and one month. The vast majority of the patients have been followed continuously for more than one and onehalf years.

The results obtained in the treatment of twenty-one primary operable patients are shown in the following table:

Table No. 3. Results — Primary Operable Patients

	No evidence of disease	Alive — Recurrent	Dead
Interstitial irradiation radical amputation (21 patients)	18	1	2
Interstitial irradiation local mastectomy (3 patients) . .	3	0	0
Irradiation alone (6 patients)	3	1	2
Total — 30 patients	24	2	4

A study of the table reveals, that of the cases treated by a combination of irradiation and radical surgery, there is a survival to date of 86 % with no evidence of the disease. The patients must be followed for a considerable period of years before the final results may be determined.

The individual alive with recurrence is a young woman 39 years of age who had a mammary tumor 7 × 6½ cm. with invaded axillary nodes and was graded »B» by the clinical index of malignancy. She has been under observation for one year and nine months. Sixteen months after the beginning of treatment, she developed extensive metastasis to the bones of the pelvis with a small recurrent nodule close to the scar. Although her disease is widespread, there is no loss of weight or strength at the present writing. Such a diffuse metastasis appearing so long a time after treatment is unquestionably not due to the method of interstitial radon implantation, but, rather to a fulminating type of the disease.

Of the two patients who have succumbed, the first was a woman 50 years of age with a tumor 5.5 × 5 cm. of rapid growth, invasion of the axilla and a grade »C» setting (highly malignant). She died eleven months after treatment, from what was reported to be a broncho pneumonia, but we strongly suspect it was, in truth, a pulmonary metastasis. The second patient who died was a young woman 34 years of age with a tumor 8 × 5 × 3½ cm. of rapid growth with extensive axillary metastasis. She was of the grade »C» highly malignant type. She succumbed one year and six months after the beginning of treatment with widespread me-

tastasis to the lungs and osseous system. In this instance, also, the course of the disease was the usual one in cases of this grade of malignancy, and the date of death was too remote from the onset of treatment to have been due to dissemination from interstitial implantation.

The three patients treated by interstitial irradiation combined with local mastectomy, are all alive to date with no evidence of disease. Two of these were of advanced age, in whom it seemed reasonable to withhold the more radical procedure. The third was a younger woman, 39 years old, with a small tumor and no axillary involvement, who was strongly opposed to a radical amputation. One was a grade »A» (low malignancy) case and two were in the lower range of grade »B» malignancy, which probably explains the satisfactory results to date.

Six of the cases in the primary operable group were treated by irradiation alone, operation being withheld because four of them were of advanced age, while the remaining two were young women with rapidly growing fulminating disease of the grade »C» type, one of whom refused any form of surgery.

Three of these patients are alive with the disease inactive for periods varying from one year and two months to one year and eight months. A fourth, 39 years of age with a tumor 7 × 6½ cm. of rapid growth with axillary metastasis is now probably recurrent with extension of the disease to the pelvic bones, the symptoms referable to this region appearing one year from the beginning of treatment. Roentgenographic plates have failed thus far to reveal pelvic bony metastasis. The fifth patient was 40 years old with a tumor 7½ × 7 cm., of rapid growth with extensive axillary disease. She succumbed to chest metastasis eight months after treatment, the pathological report being infiltrating carcinoma. Experience with the method has convinced us that disease of the type present in these younger women with large tumors and extensive axillary disease, is unsuitable for interstitial irradiation with gold radon seeds. The sixth patient was 67 years old with a tumor 6 × 4½ × 2½ cm., the course of the disease being rapid from the onset. She died one year and three months after treatment, the cause of death being unknown. This group of primary operable patients, treated by irradiation alone, is too small from which to draw dependable conclusions.

Primary Inoperable Patients

In the treatment of primary inoperable mammary cancer, experience has shown that in the presence of metastasis to the chest or osseous system interstitial irradiation had best be withheld, reliance being placed upon external irradiation; vigorous therapy, applied interstitially, would hardly appear justifiable when a palliation of such widespread disease

is the best that may be hoped for. Moreover, many of the patients in the primary inoperable group with ulcerative mammary lesions are unsuitable for treatment by the interstitial method, because of the infection already present.

The results obtained in these eleven primary inoperable patients are shown in the following tabulation:

Results — Primary Inoperable Patients

Disease inactive	Disease active	Dead
3	2	6

Of the three with inactive disease at the present time, the first is a woman 49 years of age, who had a small mammary tumor with metastasis to the axilla and chest. The breast and axilla were treated externally with x-rays, the lesion of the breast receiving 400 % S. E. D. of interstitial radon. No treatment was applied to the pulmonary disease. Histological examination showed the tumor to be an infiltrating duct carcinoma with gelatinous degeneration. The mammary tumor disappeared completely. It is now one year and eleven months since treatment was instituted and the whole process is apparently quiescent. The second patient was 48 years of age with two small tumors in the breast, each approximating 3 cm. in diameter. There was no invasion of the axilla but roentgenographic plates revealed a metastasis to the lungs. She was treated entirely by interstitial irradiation, receiving 900 % S. E. D. in the breast and 28.4 millicuries of gold radon seeds into the axilla. Biopsy after irradiation revealed a few isolated hyperchromatic cells in dense scar tissue. Complete regression of the tumor followed irradiation. She has gained in weight and is now without evidence of active disease one year and six months since the beginning of treatment. The third was a patient 37 years old with a tumor 6 cm. in diameter with axillary disease and metastasis to the lungs and pelvic bones. She received external irradiation with high voltage x-rays to the breast and metastases and 1,275 % S. E. D. with gold radon seeds in the breast. Biopsy showed a small cell highly malignant infiltrating duct carcinoma. The tumor completely disappeared and the disease has remained inactive for one year and four months.

Of the two women in whom the disease is still active, the first was 68 years old with a mass $4 \times 2^1/_2$ cm., without invasion of the axilla but with metastases to the chest and pelvic bones. She received external irradiation with high voltage x-rays to the involved areas and 960 % S. E. D. with gold radon seeds into the mammary tumor. Biopsy after external

irradiation showed a fibrocarcinoma. The lesion of the breast disappeared but the metastasis to the lungs and osseous system are progressive and now, one year and five months after treatment, a node in the corresponding axilla is readily palpable. The second was a woman 73 years of age with a tumor 3½ cm. in diameter and small invaded axillary nodes, as well as metastases to the nodes at the hilum of the lungs. Because of her age, the only treatment applied was 1,360 % S. E. D. into the mammary tumor and an implantation of 13.7 millicuries of gold radon seeds into the axilla. Biopsy ten days after irradiation showed carcinoma in scar tissue. The mass in the breast was replaced by scar tissue and the axillary nodes were no longer palpable. Ulceration at the site of the mammary tumor appeared one year and three months after treatment. At the present writing, one year and eight months following interstitial irradiation, there is obvious activity in the mammary lesion and the nodes at the hilum of the lungs are increasing in size.

Six women in the primary inoperable series have succumbed to the disease, three of them being patients upon whom a palliative mastectomy was performed because of ulceration induced by interstitial irradiation. A survey of these six patients shows that the disease was widespread when first they were seen and that the interstitial irradiation employed, probably may have shortened their lives.

Patients who are just beyond the border line of operability, because of the invasion of supraclavicular nodes, and in whom the mammary tumor is under 6 cm. in diameter, appear suitable for a combined treatment by external irradiation and interstitial implantation of gold radon seeds. Those with a single metastasis to bone without extensive mammary disease, may also be selected for treatment by this technic. The presence of ulceration or infection constitutes a contraindication to its use. Employment of this method of irradiation in well chosen cases of primary inoperable carcinoma will, we believe, yield a more effective palliation than could be obtained by the use of external irradiation alone.

Pulmonary Fibrosis

The marked inflammatory reaction attendant upon the use of the method has raised the question whether or not extensive intrathoracic fibrosis might not have been induced because of the excessive dosages employed. Roentgenographic plates of the chest have been made of the vast majority of the cases treated, and in but two instances have we been able to discover any evidence of fibrosis within the pleural cavity, these plates having been carefully studied by Dr. HERENDEEN, the roentgenologist of the Hospital. These two patients were of the primary inoperable type with extensive disease at the time of admission, both having some

metastasis to the chest and one, also, distant metastasis to the pelvic bones. In one patient a dosage of 900 % S. E. D. was used and in the second 1,275 % S. E. D. Immediately underlying the implanted seeds one could detect a slight well defined cloudiness covering an area of 6 or 8 cm. in diameter, which could be interpreted as a pleural thickening beneath the treated area. One may safely conclude that the use of interstitial irradiation presents no hazard to the patient from the standpoint of inducing serious pulmonary fibrosis. Moreover, the menace of the lethal disease being treated is far greater than that of a possible very limited intrathoracic fibrosis.

The Interstitial Use of Gold-Filtered Radon Transfixion Tubes in the Treatment of Mammary Cancer

Indications for Usage: The accurate placement of gold radon seeds in proper dosage can effect complete destruction of small mammary cancers (less than 6 cm. in diameter) as we have demonstrated by clinical experimentation and subsequent microscopical study of these breasts after amputation. Certain handicaps to universal success with this method of irradiation were early recognized. The difficulty of accurate placement of point sources of irradiation as exemplified by the method of gold radon seed implantations is particularly apparent in the treatment of tumors larger than 6 centimeters in diameter and in the treatment of outlying regions of the breast such as the axilla, infraclavicular, supraclavicular, paramammary and epigastric regions. Radiographs of the breast and drainage areas were frequently made following gold radon seed implantations; they furnished concrete evidence of the errors in the distribution of these gold seeds in large tumors and in the axilla. Amputated breasts containing large irradiated carcinomas together with axillary contents would sometimes show complete destruction of the tumor for the most part, but persistent viable carcinoma in regions which had by error escaped interstitial irradiation. Or necrotic metastatic carcinoma would be found in certain well-irradiated axillary lymph nodes, whereas other nodes untouched by and distant from the gold radon seeds in the axilla, would contain actively growing cancer. The quantity of radiant energy emitted from a gold radon seed (with 0.3 mm. Au filter) decreases so sharply at very short distances from the location of such a seed, that inaccurate placement of these seeds in the axilla or slight deviations in their distribution along the important lymphatic trunks may be responsible for the failure of interstitial irradiation in these locations. Furthermore, such errors are unavoidable and cannot be overcome by acquisition of skill, standardization of procedure or modification of dosage.

The clinical measurements of the size of mammary cancers by caliper and rule, while necessary for the calculation of tissue dosage, are fundamentally incorrect and dangerous, except for certain encapsulated tumors such as the intracystic adenocarcinomas, papillary intraductal carcinomas and bulky adenocarcinomas in their early stages, as well as certain sharply defined small tumors. In the majority of breast cancers

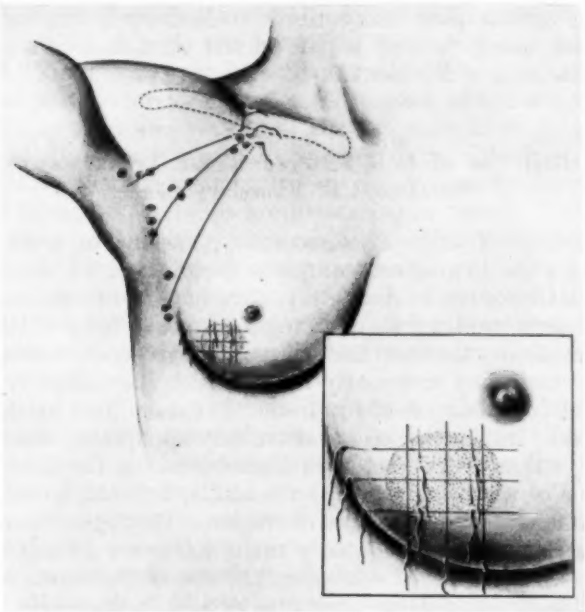

Fig. 7. To illustrate the distribution of gold radon transfixion tubes in the axilla and in a small mammary cancer. Note the attached silk threads for withdrawal of the tubes.

infiltration of cancer cells extends far beyond the palpable limits of the tumor. In such instances the palpable tumor may be completely devitalized by accurate interstitial irradiation, yet recurrence of the cancer may appear later in a part of the breast peripheral to the original tumor. It is therefore of the utmost importance to deliver a lethal dose of radiation to *all* parts of the breast which might contain infiltrating but non-palpable cancer.

The entire glandular system of the breast is condemned in certain varieties of mammary cancer. Diffuse ductal carcinoma involves the ducts in almost every lobule of the breast. Every duct is a potential site of cancer origin in the case of Paget's disease of the nipple. Even localized

carcinomas are accompanied by precancerous changes in the ducts of other lobules. We see occasionally multiple discrete cancers in the same breast; their multicentric origin can be attributed to a common underlying predisposition to cancer existent throughout the entire breast.

Principles of Application: The factors, enumerated above, and which militate against successful treatment by gold radon seeds, suggested

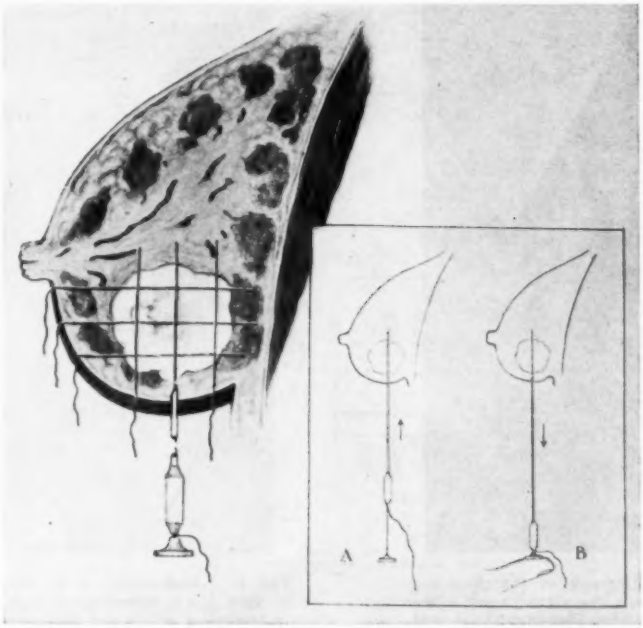

Fig. 8. Sagittal section through breast to illustrate the vertical and antero-posterior distribution of the gold radon transfixion tubes. The sketch in the insert represents the method of inserting the needle trocar containing the gold radon tube. Withdrawal of the sheath leaves the tube in place. The flexible tube is *never* pushed into the breast.

one important and imperative requirement. *The breast containing the cancer and adjacent regions of lymphatic drainage must receive diffuse rather than focal interstitial irradiation.* It occurred to one of us (G. T. P.) that the substitution of linear for point sources of irradiation would afford a more accurate placement and a more diffuse distribution of interstitial irradiation. Accordingly, we collected radon in long capillary gold tubes of 0.3 mm. filter, the length being determined in each instance by the size of the breast. These hollow gold wires are sealed at their extremities.

Waxed silk threads are attached on caps to these capillary tubes to permit their withdrawal after the proper time has elapsed.

Technic of insertion: The flexibility and small calibre of these gold capillary tubes facilitate their introduction in the same manner as implantation of gold radon seeds. They are placed within the trocar needles

Fig. 9. Radiograph of the chest and axilla to show the arrangement of the gold radon wires in the breast and axilla. The distribution can be studied much better in stereoscopic views.

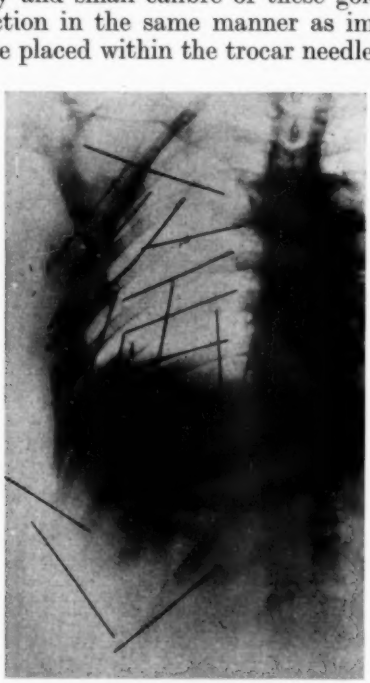

Fig. 10. Radiograph of the chest and axilla to show the arrangement of gold radon wires in the breast, axilla and paramammary regions. Supplementary interstitial irradiation was given by the implantation of gold radon seeds into several large palpable axillary lymph nodes.

with the attached threads projecting from the hilts. The tumor, breast, axilla or tissue to be irradiated is transfixed by the needle; as the needle is withdrawn the gold capillary tube is left in place, having been extruded from the needle point by gentle pressure against the wire obturator in the trocar needle.

The radon transfixion tubes are introduced in gridiron fashion so as to transfix the tumor and surrounding tissue in three planes; namely, horizontally, vertically and antero-posteriorly. The tubes are of sufficient length to extend completely through and beyond the palpable margins of the tumor in order to irradiate its environment. The ends of the wires

are well beneath the skin which is perforated only by the attached silk threads. Twelve to sixteen radon tubes suffice to irradiate the average breast and the tumor which it contains. The four or six tubes inserted antero-posteriorly are short to correspond with the thickness of the breast at the site of the tumor. The transverse tubes, also four to six in number, are slightly shorter than the width of the breast. The tubes for vertical implantation are longer in pendulous breasts. In an average

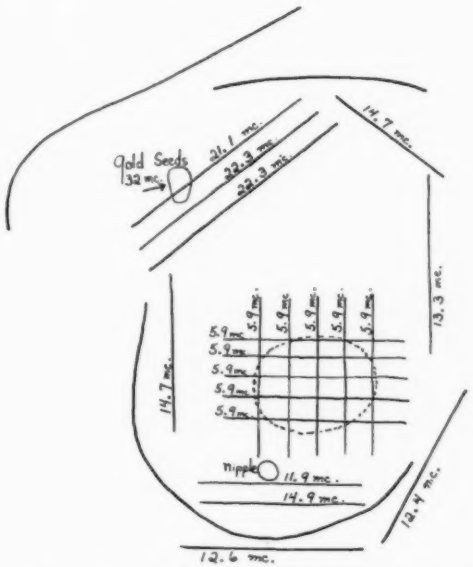

Fig. 11. H. G., a single Jewess, aged 27 years, applied to the Memorial Hospital in February, 1931 complaining of a lump in her right breast. On examination, a tumor measuring 5.5 × 5 × 4 cm. was felt in the upper segment of the right breast. There were several large firm nodes in the right axilla and one small suspicious node in the left supraclavicular space. The diagnosis was primary inoperable carcinoma of the right breast with metastases to right axilla and left supraclavicular space. Aspiration biopsy revealed carcinoma. High voltage X-ray treatments were given to the axilla, supraclavicular space, lateral and medial aspects of the breast. This treatment was followed immediately (March 19th, 1931) by the implantation of gold radon transfixion tubes which were distributed as shown in the accompanying illustration. The tubes in the axilla were 10 cm. in length; all other tubes were 7 cm. long.

Dose: Sixty-six millicuries were introduced into the axilla; the axillary tubes were withdrawn after 48 hours, having delivered a dose of 20 millicuries destroyed. Thirty-two millicuries in gold seeds were inserted directly into the palpable axillary nodes for supplementary focal irradiation. The breast and paramammary region were treated with 149 millicuries of radon in 17 gold tubes. These tubes were withdrawn in four to eight days to deliver 35 millicuries destroyed to the paramammary region and 60 millicuries destroyed to the breast proper. One gold seed containing 2 millicuries of radon was permanently implanted in the small left supraclavicular node.

The reaction in the skin and deeper tissues was intense, but had subsided completely 6 weeks later. The tumor in the breast and the palpable metastases have entirely regressed (July 16th, 1931).

case the length of the gold radon tubes might be as follows: antero-posteriorly — 4 centimeters, transversely — 6 centimeters, vertically — 8 centimeters.

In the axilla, they are inserted fanwise in order to afford diffuse and accurate irradiation to the axillary contents. The scheme for distribution of these radon tubes in the axilla calls for three tubes, each 10 centimeters

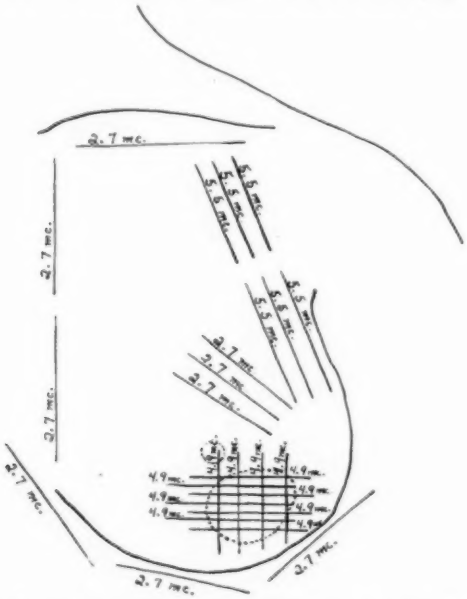

Fig. 12. M. D., a multiparous Russian woman, aged 40 years, applied to the Memorial Hospital in November, 1930, complaining of a lump in her left breast. On examination a tumor measuring $6^3/_4 \times 6 \times 5$ cm. was felt in the lower outer-quadrant of the left breast. There were several large firm nodes in the left axilla. The diagnosis was primary operable carcinoma of the left breast with metastases to left axilla. A preliminary high voltage cycle of four treatments was given to the left breast and drainage areas (November 25th, 1930). This treatment was followed (January 28th, 1931) by the implantation of gold radon transfixion tubes which were distributed as shown in the accompanying illustration. All the tubes were 5.5 cm. in length. These radon tubes were left in the breast, axilla and paramammary region for three weeks, during which time the greater part of the radon content had decayed. The dose in the axilla was 33 millicuries destroyed. The breast proper received 54 millicuries destroyed and the paramammary region — 24 millicuries destroyed. A left radical mastectomy was performed with difficulty seven weeks later. The tumor had been completely destroyed in breast and axilla. There was diffuse homogeneous fibrosis and foci of fat necrosis throughout the breast. There is no evidence of carcinoma at this time (July 16th, 1931).

in length or six tubes 6 centimeters in length. They are introduced from below upward or downward from the subclavicular region, care being taken to avoid the axillary vessels and brachial plexus at the apex of the axilla. Large axillary nodes, easily held within the grasp of the

fingers should also receive focal — and therefore more intense — irradiation by means of supplementary gold radon seeds. The gold tubes are inserted while the arm is held in abduction.

Additional gold radon tubes, 6 or 7 centimeters in length are placed deeply on the fascia, in the paramammary regions, where the principle of a circumferential barrage is employed. One tube is placed parallel to and below the clavicle; another extends diagonally across the junction of breast and epigastrium; a third tube lies along the lowermost border of the pectoral fold and, finally, an important tube is inserted parasternally. In lieu of the latter tube, small radon tubes, 2 millimeters in length, may be introduced into each intercostal space, near the sternal margin, as an attempt to block the lymphatic vessels which enter the mediastinum in this location. The attached threads for the withdrawal of the tubes are tied snugly across the breast and thereby maintain the position of the implants. The careful pursuance of this technic will avoid irradiation of the brachial plexus and consequent neuritis.

Dosage: The average gold seed is 0.4 centimeters long and contains 2 to 3 millicuries of radon. The average gold capillary tube has an initial content of 1.5 to 2 millicuries of radon to each centimeter of length, hence the intensity of irradiation is less per unit length than with the gold seeds. By this method 100 to 200 millicuries of radon are inserted within the breast and its adjacent environment; this value for radon used does not constitute the dose delivered insomuch as the tubes are withdrawn after sufficient radon has decayed to give the proper dose, in contradistinction to the gold radon seeds which are left permanently in the breast. In Table No. 2 we have shown the calculated doses in gold radon seeds for tumors of different dimensions. This data is only correct for point sources of irradiation such as afforded by the gold radon seeds. Nevertheless, we were able to arrive quickly at a satisfactory dosage by giving slightly less than the number of millicuries destroyed in gold radon tubes as would have been required if the gold radon seeds were used in a similar case. We employed the same dosage as would be used for gold radon seeds in several patients and found that the reaction of skin and mammary tissues was too great to be tolerated by the average patient. Thirty to thirty-five millicuries destroyed can be given safely in the axilla by this method. Five to eight millicuries destroyed is the dosage usually administered to each of the other paramammary regions.

Time Factor: In the case of gold radon seeds, the irradiation is continuous until the radon is completely consumed. The gold radon tubes permit the modification of the intensity of irradiation or time factor by modifying the initial strength of the content of radon and the time of irradiation which is not possible in the case of irremovable gold radon seeds. For example, the same dose in millicuries destroyed may be given

by tubes containing a large quantity of radon for a short time or by other tubes containing a small quantity of radon for a longer time. If the surgeon knows the initial value of the radon employed, the dosage planned, the rate of decay of radon and the time of implantation of the gold transfixion tubes, it is an easy matter to calculate the time required for the treatment.

The breast, axilla and paramammary region become quite red and edematous following this method of irradiation. The tissue reaction is diffuse and widespread and is intended to include the entire cancer-bearing area. After the reaction has subsided and the tumor and palpable lymph nodes have disappeared, the breast is flexible and elastic but of generally firmer texture. The axilla is not scarred sufficiently to impair the movements of the arm and shoulder. This post-radiation fibrosis is desirable, if the carcinoma has escaped complete destruction; the residual carcinoma cells may be enveloped by dense scar tissue (abortive fibrosis) where they may remain inactive for years. This status is sought for many advanced inoperable mammary cancers, but for operable carcinomas complete tumor destruction is the only satisfactory end-point for this method of irradiation.

Interstitial irradiation by gold radon transfixion tubes is absolutely contraindicated if subsequent surgery is contemplated. It is a substitute for surgery rather than a preoperative measure. Attempts at radical mastectomy after this method of irradiation have been universal failures because, (a) the scarring within the axilla prevents proper exposure of the vessels and complete dissection, and (b) wound healing after such operations is always secondary and prolonged.

This method of irradiation has been used in the treatment of fifteen patients with mammary cancer since August, 1930. Of these patients, 7 had inoperable carcinomas and 8 had operable carcinomas of the breast. The results to date have been very gratifying, when we consider the large size of the tumors selected for this treatment. For example, the five largest tumors measured 14 × 10 cm., 12 × 10 cm., 7 × 6 cm., 6.5 × 6.5 cm., and 6 × 5 cm.; all disappeared completely following irradiation and have not recurred to date.

Conclusion

The combination of external irradiation and gold radon seeds used interstitially, in measured tissue dosage, as a preoperative procedure, finds justifiable usage in selected, small, well-defined carcinomas of the breast. It cannot be recommended as a routine preoperative measure. The substitution of gold radon transfixion tubes for gold radon seeds permits greater certainty of tumor destruction and this method is more generally applicable. The technic of this method is proposed as a sub-

stitute for radical surgery alone in the treatment of mammary cancer. It can safely be advised and employed in well-selected cases wherein operation is contraindicated, because of advanced age, extreme youth — and consequent greater degree of malignancy —, the presence of intercurrent disease such as diabetes or active tuberculosis, or when the patient herself is unwilling to submit to radical amputation. The evidence at hand is sufficiently impressive and abundant to justify its employment in primary operable cancer of the breast.

SUMMARY

1. Preoperative external irradiation of mammary carcinoma is of value, as proven by: (a) Occasional regression in tumors so treated, (b) histological changes produced, (c) better clinical end results. An efficient devitalizing dose cannot be delivered by external irradiation alone.
2. To deliver an efficient dose one must use interstitial irradiation.
3. The tissue dose delivered to the tumor by external irradiation and gold radon seeds, used interstitially, should be measured and expressed in skin erythema units. This dose should be prescribed.
4. Tables prepared in the physical department enable the clinician to translate into terms of skin erythema units the tissue dose delivered, whether by external or interstitial irradiation (i. e. by gold radon seeds).
5. The clinical experiments described herein have made possible the determination of the lethal dose of irradiation for carcinoma of the breast. The tissue dosage necessary to effect destruction of a radioresistant mammary cancer 3 cm. in diameter, or less, is 12 (1,200 %) S. E. D. The devitalizing dose for the most radioresistant carcinoma, 3 to 6 cm in diameter, is at least 13 (1,300 %) S. E. D.
6. The method of gold radon seed implantation is unsuitable for tumors larger than 6 cm. in diameter.
7. The mammary gland will tolerate safely an enormous dose of interstitial irradiation.
8. Interstitial irradiation of the axilla is a difficult practical problem. Radon implants (whether gold seeds or gold tubes) should not be placed too near the apex of the axilla, less serious neuritis may ensue.
9. The possible menace of dissemination of the disease by the method of interstitial irradiation has been considered. We have not seen evidence of such dissemination in this series. Preliminary external irradiation lessens this possibility.
10. All irradiation should be given in three weeks or less time.
11. If surgery is contemplated, six weeks should elapse following interstitial irradiation before radical amputation.
12. Delayed healing of the operative wound is due to one or more of three factors:
    (a) Excessive interstitial irradiation.
    (b) Undue wound tension.
    (c) A short time interval between interstitial irradiation and surgical intervention.
13. Eighty-six percent of the patients in the primary operable group who were treated by interstitial irradiation and radical surgery are alive without

evidence of cancer, one year and six months after the beginning of treatment.

14. Pulmonary fibrosis following interstitial irradiation of the breast is of infrequent occurrence and insignificant importance.
15. The technic should not be proposed as a routine preoperative procedure. The technic of external irradiation and gold radon seeds used interstitially in measured tissue dosage, as a preoperative measure finds justifiable usage in selected, small, well-defined carcinomas of the breast.
16. Finally our experience in the evolution of methods for the irradiation of mammary cancer forces the conclusion that the technic of gold radon transfixion tubes in the breast, axilla and paramammary regions, offers the most effective means yet devised, for the destruction of mammary cancer and its accessible metastases. It should never be employed as a preoperative measure but may well be considered as a substitute for radical surgery.

ZUSAMMENFASSUNG

1. Präoperative externe Bestrahlung des Mammakarzinoms ist wertvoll; dies ist bewiesen durch: A) Mitunter vorkommende Rückbildung derart behandelter Tumoren, B) Auftreten histologischer Veränderungen, C) Bessere klinische Endresultate. Eine wirksam abtötende Dosis ist durch externe Bestrahlung allein nicht zu erreichen.
2. Zur Erzielung einer solchen Dosis muss man interstitielle Bestrahlung anwenden.
3. Die dem Tumor durch externe Bestrahlung und interstitiell implantierte Gold-Radium-seeds zugeführte Gewebsdosis soll gemessen und in Hauterythem-Einheiten angegeben werden.
4. In der physikalischen Abteilung aufgestellte Tabellen ermöglichen es dem Kliniker, die durch Oberflächen- oder durch interstitielle Bestrahlung, (d. h. mittels Gold-Radium-seeds) verabreichte Gewebsdosis in Form von Hauterythemeinheiten auszudrücken.
5. Die in der Arbeit beschriebenen klinischen Versuche haben die Bestimmung der abtötenden Bestrahlungsdosis für Brustkrebs ermöglicht. Die zur Zerstörung eines radioresistenten Mammakarzinoms mit einem Durchmesser von 3 cm oder weniger notwendige Gewebsdosis beträgt 12 (1,200 %) HED. Die Abtötungsdosis für Karzinome von der grössten Radioresistenz und 3—6 cm Durchmesser beträgt mindestens 13 (1,300 %) HED.
6. Für Tumoren, die einen grösseren Durchmesser haben als 6 cm ist die Methode der Implantation von Gold-Radium-seeds nicht geeignet.
7. Die Brustdrüse verträgt ohne Gefahr eine enorme Dosis von interstitieller Bestrahlung.
8. Interstitielle Bestrahlung der Axilla ist ein schwieriges praktisches Problem. Radium-Implantierung (Gold-seeds oder Röhrchen) sollen nicht zu nahe an dem Apex der Axilla vorgenommen werden, weil dies eine ernste Neuritis zur Folge haben kann.
9. Die Verfasser haben der möglichen Gefahr einer Dissemination der Krankheit durch die Anwendung von interstitieller Bestrahlung Beachtung geschenkt. Sie sahen indes in den vorgelegten Serien keine Beweise einer solchen Dissemination. Vorausgeschickte externe Bestrahlung verringert diese Möglichkeit.

10. Die gesamte Bestrahlung soll binnen drei Wochen oder in einem kürzeren Zeitraume vorsichgehen.
11. Wenn operative Behandlung in Erwägung gezogen wird, sollen zwischen der interstitiellen Bestrahlung und der folgenden Radikalamputation sechs Wochen verflossen sein.
12. Verzögerte Heilung der Operationswunde beruht auf einem oder mehreren der folgenden 3 Faktoren:
    A. Übermässige interstitielle Bestrahlung.
    B. Übertriebene Spannung bei Vereinigung der Wundränder.
    C. Zu kurzes Zeitintervall zwischen interstitieller Bestrahlung und dem chirurgischen Eingriff.
13. Sechsundachtzig Prozent von den Fällen der primär operablen Gruppe, die interstitieller Bestrahlung und radikaler Operation unterzogen worden waren, sind $1^1/_2$ Jahre nach Beginn der Behandlung am Leben und zeigen keine Symptome von Karzinom.
14. Fibrose der Lungen im Gefolge von interstitieller Bestrahlung der Brust ist ein seltenes Vorkommnis und von untergeordneter Bedeutung.
15. Die Technik der externen Bestrahlung und Gold-Radiumnadeln-Implatation in gemessener Gewebsdosis soll nicht schablonmässig als voroperatives Verfahren angewendet werden. Ihre gerechtfertigte Anwendung als präoperative Massnahme findet diese Technik bei ausgewählten, kleinen, scharf umschriebenen Brustkrebsen.
16. Schliesslich zwingt unsere Erfahrung in der Entwicklung der Methoden für die Bestrahlung des Mammakarzinoms zu dem Schluss, dass die Gold-Radium-Implantationsröhrchen in der Brust, Axilla und in den paramammären Regionen die wirkungsvollste von den bisher ersonnenen Methoden zur Zerstörung des Brustkrebses und seiner zugänglichen Metastasen bietet. Sie soll niemals als präoperative Massnahme angewendet werden, mag aber wohl als ein Substitut für radikaloperative Behandlung betrachtet werden.

RÉSUMÉ

1. L'irradiation externe pré-opératoire du cancer mammaire a fait ses preuves: A) dans les cas de régression occasionnelle du néoplasme ainsi traité; B) dans les cas de modifications histologiques; C) par un résultat clinique final meilleur. Une dose effectivement dévitalisante ne peut être administrée par l'irradiation externe seule.
2. Si l'on veut obtenir une dose effective, il faut recourir aux irradiations interstitielles.
3. La dose histologique administrée par irradiation externe et au moyen de »gold radon seeds» par la voie interstitielle doit être mesurée et exprimée en unités d'érythème cutané. C'est cette dose qui sera prescrite.
4. Des tables établies par le laboratoire de physique permettront au clinicien de transformer en unité érythémateuse la dose histologique administrée, qu'il s'agisse d'irradiation externe ou interstitielle.
5. Les expériences cliniques décrites ici ont permis de déterminer la dose mortelle d'irradiations pour le cancer mammaire. La dose histologique nécessaire pour obtenir un effet destructif sur un cancer mammaire radiorésistant de 3 cm. de diamètre, ou moins, est de 12 (1200 %) S. E. D. La dose dévitalisante pour les cancers les plus radiorésistants de 3 à 6 cm. de diamètre est d'au moins 13 (1300 %) S. E. D.

6. La méthode d'implantation de radium-or est inapplicable aux tumeurs de plus de 6 cm de diamètre.
7. La glande mammaire supporte des doses énormes d'irradiation interstitielle.
8. L'irradiation interstitielle du crux axillaire est un problème difficile. L'implantation de radium, qu'il s'agisse de »semences» ou de tubes d'or, ne doit pas être appliquée trop près du sommet axillaire, sous peine de déterminer de graves névrites.
9. L'auteur a envisagé le risque possible de dissémination de la lésion par la méthode interstitielle. Ce risque n'a paru évident dans aucune de nos séries cliniques. Une irradiation externe préliminaire atténue ce risque.
10. Toute irradiation doit être appliquée 3 semaines ou moins.
11. Si on envisage une intervention chirurgicale, on devra observer un délai de 6 semaines entre l'irradiation et l'amputation radicale.
12. Les retards apportés à la guérison de la plaie opératoire peuvent tenir à un ou à plusieurs des trois facteurs suivents:
    A) Irradiation interstitielle excessive;
    B) Tension exagérée de la plaie;
    C) Intervalle trop réduit entre l'irradiation et l'opération.
13. 86 % des malades du groupe primairement opérable ayant subi le traitement mixte par irradiations interstitielles et opération radicale survivaient sans symptômes apparents 18 mois après le début du traitement.
14. La sclérose pulmonaire consécutive aux irradiations interstitielles du sein n'est ni fréquente ni inquiétante.
15. Cette technique ne saurait être proposée comme une technique préopératoire applicable à tous les cas. La technique des irradiations externes et interstitielles par doses histologiques déterminées est, en tant que mesure préopératoire, justifiée dans les cas de cancer mammaire choisis, de peu d'étendue et bien délimités.
16. Enfin, notre expérience acquise dans l'évolution de la méthode d'irradiation du cancer mammaire, conduit à cette conclusion, que la technique de transfixion par des tubes de radium au niveau du sein, du creux axillaire et de la région para-mammaire est actuellement le meilleur procédé dont on dispose pour la destruction du cancer mammaire et de ses métastases accessibles. Cette méthode ne sera jamais appliquée comme mesure pré-opératoire, mais constitue un procédé substitutif à l'intervention chirurgicale.

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ZUR FRAGE DER ENTSTEHUNG KARDIANAHER MAGENDIVERTIKEL UND ZENKERSCHER OESOPHAGUSDIVERTIKEL. ZUGLEICH EIN BEITRAG ZUM SCHLUCKMECHANISMUS[1]

von

Hugo Laurell.

(Tabula XLVIII)

Die Pathologen kennen seit lange die organischen Magendivertikel. Diese sind bekanntlich relativ selten und werden, wie angegeben wird, an zwei Prädilektionsstellen angetroffen: in der Nähe des Pylorus und in der Nähe der Kardia. Manche sind kongenital, andere erworben. In der Nähe des Pylorus hat man wiederholt bei Sektion nachweislich kongenitale kleine Divertikel gefunden, die aus allen Wandschichten des Ventrikels gebildet waren und Pankreasgewebe enthielten. In derselben Gegend sind auch kleine Divertikel ohne Pankreasgewebe festgestellt worden. BROMAN glaubt, dass sowohl Divertikel mit als solche ohne Pankreasgewebe nur verschieden weit reduzierte Pankreasanlagen darstellen können. Nach der Darstellung von BROMAN wären für das atavistische Auftreten eines Pankreasdivertikels am Magen nur die kaudalen Teile in Betracht zu ziehen.

Auch die Divertikel in der Kardiagegend sind früher oft als kongenital betrachtet worden, eine Ansicht, deren Richtigkeit für die Mehrzahl der Fälle in Frage gezogen werden kann, namentlich im Hinblick auf die in den letzten Jahren gemachten Erfahrungen über die Verteilung der Fälle nach Alter und Geschlecht (siehe unten).

Von Röntgenologen hat CARMAN als erster die Divertikel in seinem die Röntgendiagnostik des Verdauungstraktus behandelnden Buch erwähnt. Aber erst nach ÅKERLUNDS grundlegender Arbeit über Magendivertikel von 1923, die sich auf 6 in der Nähe der Kardia sitzende »kon-

[1] Bei der Redaktion am 17. IX. 1931 eingegangen.

genitale» und einen erworbenen Divertikel im Canalis bezieht, ist der Blick der Röntgenologen für dieses Leiden geschärft worden, das in der Regel ohne Symptome verläuft. Die noch immer wachsende röntgenologische Kasuistik über insbesondere »kardianahe Divertikel» — eine von FLEISCHNER eingeführte Bezeichnung — zeigt, dass dieses Leiden gewöhnlicher ist, als die Sektionsbefunde vermuten lassen. Auf der hiesigen Abteilung sind 3 Fälle von Divertikeln in der Nähe der Kardia und 1 auf der lateralen Seite des Fornix beobachtet worden. Von diesen Fällen betrafen zwei Männer; zwei der Fälle zeigten das von ÅKERLUND beschriebene typische Röntgenbild; einer der Fälle, der namentlich in bezug auf seinen Verlauf von dem gewöhnlichen Bilde abwich, soll nachstehend näher beschrieben werden.

Fall eines Divertikels bei einem 18jährigen Mädchen

Pat. ziemlich mager. Seit ½ Jahr periodisch Ulkusbeschwerden. Im direkten Anschluss an eine Probemahlzeit wurde eine *Röntgenuntersuchung* vorgenommen. Der Ventrikel zeigte eine ausgesprochene Ptosis und das Duodenum eine ulkusverdächtige En-face-Nische, die erst bei Kompression des Bulbus sichtbar war. Zwerchfellkuppeln gesenkt, Lungen emphysematös. Das Herz im Stehen mediangestellt und schmal, ein typisches Tropfenherz, das lebhaft pulsierte.

Im Stehen zeigte der Ventrikel eine hohe Intermediärschicht. Innerhalb dieser zeichnete sich ein kontrastgefülltes, krachmandelgrosses, tropfenförmiges Divertikel mit gleichmässigen Konturen ab (Figg. 1 und 2). In demselben war keine Gasblase sichtbar. Es lag auf der Rückseite des Ventrikels, einige Zentimeter lateral unterhalb der Kardia, wie aus Untersuchungen in verschiedenen Projektionen und bei Passage von Kontrast durch die Kardia hervorging. Der Kontrast sank längs dem Sulcus salivalis einige Zentimeter medial vom Divertikel hinab. Infolge der starken Herzpulsationen pulsierten auch die oberen Teile des Ventrikels und das Flüssigkeitsniveau unterhalb der Magenblase lebhaft. Auch die Kontrastmasse im Divertikel führte im Stehen eine auf- und abwärts gehende Bewegung von einigen Millimetern aus, weshalb es schwer war, scharfe Bilder des Divertikels zu erhalten.

Um das Aussehen des Divertikels festzustellen, wurde Pat. auch im Liegen untersucht, aber hierbei konnte man überraschenderweise kein Divertikel wahrnehmen, wie man auch die Patientin drehte. Im Glauben, dass das Divertikel nun verschwunden sei, wurde Pat. abermals im Stehen untersucht; aber jetzt wurde es an seiner alten Stelle mit unverändertem Aussehen angetroffen. Erneuter Versuch, das Divertikel im Liegen zu sehen, misslang, aber bei aufrechter Körperstellung war es immer wieder wahrnehmbar.

Nach den erwähnten Untersuchungen glaubte Verf. anfangs, dass das Divertikel in einer Schleimhautpropulsion bestehe, die im Liegen verschwinde — retrahiert werde —, und zwar, weil dann Fornix und Corpus (vor allem bei Rückenlage) von der Kontrastmasse ausgedehnt wurden. Zwecks näherer Untersuchung des Divertikels wurde Pat. aufgefordert, am nächsten Tage mit nüchternem Magen wiederzukommen. In der Hoffnung, sehen zu können, wann und wie sich das Divertikel mit Kon-

Fig. 1.

Fig. 2. Der Divertikel in natürlicher Grösse.

trast füllte, wurde nun verfolgt, wie das Lumen des Ventrikels vom ersten bis zum letzten Bissen mehr und mehr durch den Kontrastbrei erweitert wurde. Aber diese Erwartung wurde getäuscht. Das Divertikel füllte sich weder in der einen noch in der anderen Körperstellung. Nicht einmal durch Verstärkung des intraventrikularen Druckes mittelst manueller Kompression gelang es, die Ausstülpung eines Divertikels herbeizuführen. Fig. 3 zeigt das Aussehen des Ventrikels im Stehen bei dieser Gelegenheit.

Dieser Fall eines Divertikels in der Kardiagegend ist in mehreren Beziehungen ungewöhnlich. Es war nur in aufrechter Stellung und nur bei *einer* Untersuchung sichtbar, sass einige Zentimeter lateral von der Kardia und wurde in ungewöhnlich frühem Alter, 18 Jahre, festgestellt. Keiner der röntgenologisch diagnostizierten Fälle von kardianahen Di-

vertikeln, die ich in der Literatur finden konnte, ist in so frühem Alter konstatiert worden. In der überwiegenden Mehrzahl der Fälle hat es sich um Personen in mittlerem oder höherem Alter gehandelt. Im Hinblick auf die soeben erwähnten ungewöhnlichen Eigenschaften des Divertikels kann man sich fragen, ob es nicht vielleicht eine andere Genese hat als die von ÅKERLUND u. a. beschriebenen typischen Divertikel in der Kardiagegend. In Anbetracht seiner Lage an der hinteren Wand des Ventrikels einige Zentimeter lateral unterhalb der Kardia mit der Mündung ungefähr in der Fortsetzung des intraabdominalen Teiles der Speiseröhre kann man die Frage aufwerfen, ob es nicht infolge der Einführung des Magenschlauches in den Ventrikel während der Minuten vor der Röntgenuntersuchung entstanden ist. Der benutzte Schlauch war jedoch von gewöhnlicher Art, fingerweit, steif und mit konischem Ende versehen. Wenn der Schlauch beim Einführen in den Ventrikel gegen eine Schleimhautfalte gestossen wäre und sich daran festgehakt hätte, so hätte theoretisch bei seiner weiteren Einführung eine Schleimhautpropulsion entstehen können, vorausgesetzt, dass die Muskelwandung an der entsprechenden Stelle schwach war oder eine abnorme Lücke hatte. Man muss in diesem Zusammenhang unwillkürlich an die rezessartige Vorwölbung der kephalen Wand der Harnblase denken, die um die Spitze eines Zystoskops entsteht, wenn dieses unnötig tief in eine mit Kontrastlösung gefüllte Blase eingeführt wird und letztere wenig gespannt ist. Die oft mehrere Zentimeter lange Ausstülpung umschliesst dann in der Regel das Zystoskop so dicht, dass man sich, wenn man zum ersten Male ein solches Röntgenbild sieht, einbilden kann, das Instrument habe die Blasenwand durchbohrt. Gegen die Hypothese, dass das Magendivertikel in meinem Fall möglicherweise bei Herablassung des Magenschlauches in den Ventrikel entstanden ist, könnte man einwenden, dass diese Massnahme der Patientin keine nennenswerten Beschwerden verursacht hat. Jedoch ist die Frage damit nicht entschieden, denn das schmerzempfindliche Peritoneum parietale braucht ja bei einem solchen Insult der Ventrikelwand nicht nennenswert in Mitleidenschaft gezogen worden zu sein.

Fig. 3.

Bei der ersten Untersuchung des vorstehend beschriebenen Divertikelfalles gelangte Verf., wie gesagt, zu der Auffassung, dass das Divertikel beim Liegen infolge der Ausdehnung der umgebenden Ventrikelteile verschwinde. Bei Besprechung des Falles mit Dr. ARNELL wies dieser auf eine andere Möglichkeit hin, dass nämlich das Divertikel auch im Liegen vorhanden, aber dann nicht sichtbar war, weil es im Niveau mit der umgebenden Ventrikelwand lag und von der umgebenden Kontrastmasse verdeckt wurde. Wie, zeigt nebenstehendes Schema (Fig. 4). Diese Erklärung erschien mir bei näherer Überlegung wohl annehmbar und besser in Übereinstimmung mit der oben aufgestellten Hypothese von der traumatischen Genese des Divertikels. Denn warum sollte das Divertikel, wenn es bei Einführung des Magenschlauches entstanden war, nach spontaner Reposition im Liegen so grosse Neigung haben, sich bei aufrechter Körperstellung wiederzubilden? Zieht man ferner in Betracht, dass das Divertikel an der hinteren Ventrikelwand hoch oben ungefähr in der Höhe der Nebenniere oder der Niere lag und dass diese Ventrikelwand in grosser Ausdehnung mit ebener Oberfläche dicht an der hinteren Bauchwand anliegt und daselbst eine relativ feste Stütze hat, so begreift man leicht, dass diese Lage das Divertikel hindert, sich nischenartig über die umgebende Ventrikelfläche zu erheben. Eine solche Vorstülpung in die hintere Bauchwand hinein würde ja voraussetzen, dass sich in letzterer eine grosse Lücke befand bzw. durch den Magenschlauch gebildet wurde, oder auch, dass das retroperitoneale Fettgewebe in dieser Gegend sehr reichlich und nachgiebig war, so dass es einem sich vorwölbenden Divertikel keinen nennenswerten Widerstand leistete. Aber es ist höchst unwahrscheinlich, dass sich eine präformierte Lücke in der hinteren Bauchwand gerade an der Stelle einer durch den Magenschlauch hervorgerufenen Schleimhautpropulsion befand oder dass der Magenschlauch eine solche Läsion herbeiführen konnte. Aber auch die dritte Voraussetzung für die Entstehung eines Divertikels an der erwähnten Stelle vor der Niere oder Nebenniere ist nicht gegeben, denn in der Regel ist das vor diesen Organen liegende retroperitoneale Fettgewebe sparsam entwickelt, namentlich bei mageren Patienten.

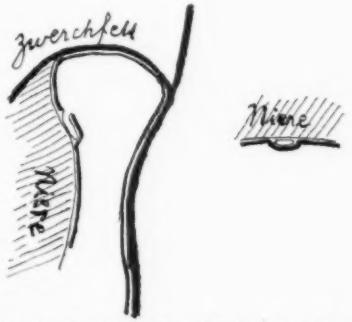


Fig. 4. Sagittal-bezw. Querschnitt durch den Divertikel.

Da das Corpus ventriculi normalerweise hinten von der festen hinteren Bauchwand gestützt wird, sind Divertikel von Pulsionstypus hier

natürlich viel seltener als auf der Curvatura-minor-Seite, wo sich solche Divertikel nischenartig in medialer Richtung zwischen dem linken Leberlappen und der hinteren Bauchwand vorwölben können. Hierzu kommt, dass auf der Minorseite unterhalb der Kardia bisweilen eine

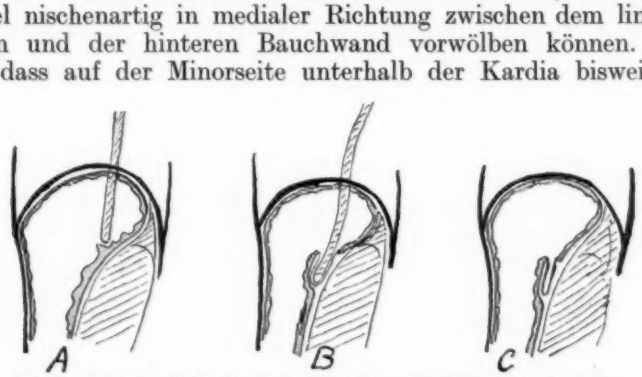


Fig. 5. Sagittalschnitt durch den Ventrikel und das Retroperitoneum.

A zeigt, wie die Schlauchspitze von einer Schleimhautfalte gefangen wird.

B zeigt das Aussehen, wenn die Schleimhaut durch eine schwache Stelle in der Tunica muscularis vorgedrückt ist.

C zeigt das voll ausgebildete Divertikel nach Entfernung des Schlauches. Das Divertikel gleicht nun, vom Ventrikellumen aus gesehen, in gewisser Weise einem von der Wand vorspringenden Schwalbennest.

Schwäche der Tunica muscularis besteht, die zu solcher Divertikelbildung disponiert (hierüber später). Entsteht ein Pulsionsdivertikel auf der Hinterseite des Corpus an einer Stelle, wo die hintere Bauchwand eine ebene Oberfläche hat und eine feste Stütze bietet, so wird es wahrscheinlich, wie oben angedeutet, eine lokale Impression auf der hinteren Oberfläche des Ventrikels hervorrufen und infolgedessen selbst gleichsam in einer Nische in der Ventrikelwand eingesenkt liegen. Entsteht das Divertikel durch Einführung eines Magenschlauches, so kann man sich den Entstehungsmechanismus so denken, wie obenstehende Figur 5 zeigt.

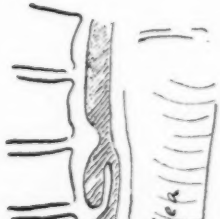


Fig. 6

Das hier abgebildete Magendivertikel hat, wie man sieht, grosse Ähnlichkeit mit einem kleinen Zenkerschen Oesophagusdivertikel (siehe Fig. 6). Das Zenkersche Divertikel sitzt bekanntlich immer an einer typischen Stelle am Übergang zwischen Pharynx und Oesophagus und sprosst nach hinten kaudalwärts in der Richtung auf die Wirbelsäule. Infolge von Platzmangel übt es einen Druck auch auf die Speiseröhre aus und erzeugt eine Impression auf deren hinterer Wand. Aber da die leere Speiseröhre einen Spaltraum hat, verschiebt das Divertikel auch die vordere Wand der Speiseröhre

nach vorn gegen die Trachea hin. Hieraus entstehen bekanntlich Schluckbeschwerden, wenn das Divertikel gross und gut gefüllt ist. In bezug auf die Ursachen der erwähnten Oesophagusdivertikel und der in der Nähe der Kardia sitzenden typischen Magendivertikel bestehen nach Ansicht des Verf. interessante Übereinstimmungen, die später erörtert werden sollen. Zuvor will ich indes einen kürzlich von BRÜCKNER veröffentlichten Fall eines Magendivertikels besprechen, der stark an meinen oben beschriebenen Fall erinnert.

Brückners Fall eines Magendivertikels

Das Divertikel wurde bei einer 38jährigen Frau angetroffen und lag in der Nähe der Kardia. Es war deutlich gestielt und sass wie in meinem Fall auf der Rückseite des Corpus, lateraler, als es gewöhnlich der Fall ist. Es zeigte ferner wie in meinem Fall deutliche Pulsationen, die BRÜCKNER auf die Nachbarschaft der Aorta zurückführt, allerdings mit Unrecht wegen des grossen Abstandes von der Wirbelsäule. B. beobachtete, wie der Kontrast sogleich in den Magen hinabsank, und deutete dies als Ausdruck einer Atonie des letzteren. Aber wenn man seine Abbildung betrachtet, gewinnt man mehr den Eindruck eines »normotonischen» Ventrikels mit hoher Intermediärschicht, und da aus der Darstellung hervorzugehen scheint, dass unmittelbar vor der Röntgenuntersuchung eine Probemahlzeit heraufgeholt worden war, kann man vermuten, dass die Intermediärschicht teilweise auf Resten der Probemahlzeit beruhte und dass sich das rasche Hinabsinken der ersten Kontrastbissen gerade durch den Flüssigkeitsgehalt, nicht durch eine Atonie erklärt. Dies wird hier betont, weil B. in der erwähnten Atonie eine wesentliche Ursache für die Ausbildung des Magendivertikels erblickt. Nach $2^1/_2$ Stunden war das Divertikel unsichtbar und der Ventrikel leer. Die rasche Entleerung beider erklärt B. so, dass die Ausdehnung des Divertikels reflektorisch einen gesteigerten Kontraktionszustand des Ventrikels und dadurch eine rasche Entleerung des letzteren und des Divertikels auslöste. Diese Erklärung ist unverständlich, wenn man wie B. die Ausstülpung als ein Pulsionsdivertikel auffasst. Wie kann ein erhöhter intraventrikularer Druck ein Pulsionsdivertikel zum Verschwinden bringen?! Kann das Divertikel nicht auch hier durch den Magenschlauch hervorgerufen sein? Alsdann kann das Fehlen von Retention im Divertikel nach $2^1/_2$ Stunden entweder so gedeutet werden, dass das Divertikel bald nach seinem Auftreten spontan reponiert worden ist, oder dass es sich durch zufälliges Einnehmen einer geeigneten Körperlage entleert hat. Bei erneuter Untersuchung nach 4 Monaten war das Divertikel nicht sichtbar; die Ursache hierfür erblickt B. darin, dass sich

der Ventrikel bei dieser Gelegenheit in einem stärkeren Kontraktionszustand befand als bei der ersten Untersuchung.

Einiges über die Ursachen der typischen kardianahen Magendivertikel

Die Mehrzahl dieser Fälle ist röntgenologisch diagnostiziert, aber nicht durch Operation oder Sektion kontrolliert worden. Zu urteilen teils nach den Röntgenbildern (blasenartige Form, wechselnde Grösse, enger Hals usw.), teils nach den vereinzelten Fällen, in denen Operation oder Sektion stattgefunden hat (FLEISCHNER, KOPPENSTEIN u. a.), sind die nahe der Kardia sitzenden Magendivertikel wahrscheinlich in der Hauptsache hernienartige Ausstülpungen der Mucosa durch Lücken der muskulären Wandungen. Dies ist die Ansicht vieler Autoren. Oft werden diese Divertikel als kongenital bezeichnet, womit man meint, dass sie auf einer latenten kongenitalen Anlageschwäche der Muskelwandung beruhen, die jedoch erst in späterem Alter zu der krankhaften Wandveränderung führt. Es erscheint indes unangebracht, das Wort kongenital in diesem Sinne zu gebrauchen, denn mit ebensoviel Recht könnte man dieselbe Bezeichnung für viele der in höherem Alter an typischen Stellen auftretenden Brüche anwenden, unter anderem für Femoralbrüche und direkte Leistenbrüche, die man allgemein als erworben betrachtet. Im übrigen lässt sich schwer beweisen, dass die Schwäche der Muskelwand des Ventrikels, die sich unterhalb der Kardia infolge der Anordnung der dortigen Muskulatur findet, so wesentliche Bedeutung für die Entstehung der fraglichen Magendivertikel hat, dass man berechtigt wäre, sie als kongenital zu bezeichnen. Andere allmählich im Laufe des Lebens auftretende, zu Divertikelbildung disponierende Faktoren haben vielleicht noch grössere Bedeutung. Hierüber später.

FLEISCHNER nimmt wohl mit Recht an, dass eine örtliche anatomische Anlage für die kardianahen Magendivertikel besteht, da sie in der Regel an derselben Stelle auf der Rückseite des Ventrikels dicht unterhalb der Kardia auftreten. Als Ursache bezeichnet er eine Schwäche der Muskelwand an dieser Stelle. Dagegen schreiben HIRSCH und THOREL den Durchtrittsstellen der Gefässe in der Muskulatur als Locus minoris resistentiae bei der Divertikelbildung besondere Bedeutung zu. Eine Schwäche oder Lücke der Muskelwand kann auch einmal an anderen Stellen des Magens, vor allem an der grossen Kurvatur, einen Schleimhautdivertikel veranlassen. Köntzey beschreibt ein solches, klein apfelgrosses Divertikel am untersten Pol der grossen Kurvatur. Dieses war zwischen die beiden Blätter des Lig. gastrocolicum vorgedrungen und liess sich in den Magen invaginieren. Die Stelle, an der die kardianahen Divertikel entstehen, ist ferner nach THOREL, ZAHN und FLEISCHNER ständigen mechanischen Insulten ausgesetzt, da die flüssi-

gen Speisen hier anprallen und zur Vorbuchtung der schwachen Magenwand führen sollen. Nach FLEISCHNER spielt diese mechanische Belastung eine wesentliche Rolle wenigstens für das Wachstum des Divertikels. Indes scheint mir die Bedeutung der erwähnten mechanischen Insulte überschätzt zu werden. Man kann allerdings bisweilen sehen, wie sich das Divertikel beim Verzehren der ersten Kontrastbissen füllt und anscheinend ausdehnt. Diese Ausdehnung kann jedoch grossenteils scheinbar sein und auf einer Senkung und Umformung des dünnwandigen und bis zu gewissem Grade verschiebbaren Divertikels unter dem Einfluss der spezifisch schweren Kontrastmasse beruhen. Schon vor Verzehren des Kontrastes ist das Divertikel oft ausgebildet, aber nur sichtbar, wenn es mit Luft gefüllt ist, was häufig beim Stehen und bei Bauchlage der Fall ist. Dass es infolge der Schwere der Kontrastmasse verschiebbar ist, hat KOPPENSTEIN gezeigt, indem er den Patienten auf die rechte Seite legte, wobei sich das Divertikel nach rechts mehr über die Ventrikelwand erhob. Die Vergrösserung des Divertikels, die bisweilen nach Genuss einer grösseren Menge Kontrast beobachtet wird, dürfte mehr auf der allgemeinen intraventrikularen Drucksteigerung beruhen als auf dem Gewicht der kleinen im Divertikel liegenden Kontrast- und Flüssigkeitsmenge, wenn auch natürlich dieser letztere Faktor nicht ganz übersehen werden darf, namentlich, wenn das Divertikel grössere Dimensionen erlangt hat. Noch weniger verständlich ist die oben erwähnte Ansicht, dass der Anprall der Speisen beim Schlucken wesentliche Bedeutung für die Entstehung eines Divertikels habe. Denn erstens entwickelt sich das Divertikel nicht immer von der Wandpartie aus, die zuerst von den durch die Kardia herabgleitenden oder herabrinnenden breiigen oder flüssigen Speisen getroffen wird, und zweitens stürzt, wie man leicht bei Kontrastpassage sehen kann, der Inhalt der Speiseröhre nicht mit grosser lebendiger Kraft in den Magen, nicht einmal, wenn es sich um Flüssigkeiten handelt. Das Herabgleiten des Inhalts beruht ja vor allem auf der Peristole und Peristaltik der Speiseröhre, erst in zweiter Linie auf der Konsistenz und Viskosität der Kontenta sowie auf der Schwere und Höhe der Flüssigkeitssäule, und zwar trotz aufrechter Stellung. Dies erklärt sich bekanntlich teils daraus, dass die oberen Teile der Speiseröhre geschlossen sind, wenn sich die Kardia öffnet, so dass der äussere Luftdruck die Entleerung nicht direkt beeinflussen kann, teils aus dem negativen intrathorakalen Druck, welcher der Entleerung der Speiseröhre entgegenwirkt. Damit sich die Speiseröhre bei offener Kardia rasch und mit Kraft in den Ventrikel entleeren könnte, wäre ein anhaltender hoher Überdruck im Oesophagus im Verhältnis zum Ventrikel erforderlich. Ein solcher entsteht indes nicht einmal während der Peristaltik der Speiseröhre, weil diese relativ langsam ist. So kann man bei Durchleuchtung leicht sehen, dass halb-

flüssige Kontrastmasse nur langsam als ein zusammenhängender Kontraststrang durch die Kardia herabgepresst wird, der sich, wenn er aufgehalten wird, oft wie ein Sirupstrang ringelt. Aber auch flüssiger Kontrast stürzt in der Regel nicht wie aus der Wasserleitung herunter, sondern rinnt langsam an den Wänden des Ventrikels hinab. Ein Magendivertikel in der Kardiagegend wird jedoch auch durch eine langsam hinabrinnende Kontrastmasse vergrössert und prominenter. Dies beweist, dass nicht der Anprall das wesentliche ursächliche Moment ist.

Nach dem oben Gesagten kann der mechanische Insult, den gewöhnliche Nahrung bei ihrem Hinabdringen in den Magen ausübt, keine wesentliche Bedeutung für die Entstehung der hier erörterten Magendivertikel haben. Eine ganz andere und stärkere örtliche Druckwirkung kann offenbar durch einen Magenschlauch hervorgerufen werden, wenn er sich an einer schwachen Stelle der Muskelwand anhakt. Ob und wie oft unter solchen Umständen Divertikel, vorübergehende oder bleibende, entstehen, ist indes eine Frage, die noch nicht spruchreif ist. Ein solches traumatisches Magendivertikel wird sicher bei weiterem Herablassen des Magenschlauches bis zu gewissem Grade vergrössert, aber die Gefahr einer Perforation der Wand ist doch minimal, da die Schleimhaut auch post mortem zähe und schwer zu durchbohren ist. Wenn sich das Divertikel maximal ausgedehnt hat, wird sich der Magenschlauch bei weiterem Hinablassen im Ventrikel ringeln, wobei die Spitze des Schlauches aus dem Divertikel herausgleiten kann.

Bársony hat eine kühne Theorie über die Ursachen von Divertikeln überhaupt aufgestellt, der sich Koppenstein hinsichtlich der hier erörterten Magendivertikel angeschlossen hat. Diese Autoren nehmen an, dass es analog den regionalen und den Fernspasmen des Ventrikels auch regionale und Fernmuskeldepressionen (Relaxationen) gibt, die auf einem organischen Leiden in der Nähe oder entfernt von diesen Relaxationen beruhen. B. ist der Ansicht, dass mit dieser Relaxation eine Inaktivitätsatrophie ensteht, die, wenn sie Prädilektionsstellen für Divertikel trifft, zu solchen Divertikeln führen kann. Solche Prädilektionsstellen sind nach ihm die ab ovo schwächeren Stellen der Magenwand und ferner Gefäss- und Nervenlücken, die infolge der erwähnten Muskelatrophie noch mehr erweitert werden.

Von den 34 röntgenologisch nachgewiesenen Fällen von Magendivertikeln in der Kardiagegend mit Angabe des Lebensalters, die Verf. zusammenstellen konnte, sind alle, ausser meinem oben beschriebenen Fall bei einer 18jährigen Patientin, nach vollendetem 25. Lebensjahr und in der Regel erst im mittleren Alter oder später angetroffen worden. Dies gibt Anlass zu der Vermutung, beweist aber nicht, dass die Divertikel in der Regel erst bei Erwachsenen entstehen, denn wir müssen bedenken, teils, dass die Divertikel selbst keine Beschwerden verursachen

und daher gewöhnlich nur als Nebenbefund bei Röntgenuntersuchung festgestellt werden, teils, dass der Ventrikel selten vor der Pubertät und noch seltener im Kindesalter zur Röntgenuntersuchung gelangt. So handelte es sich bei 1,000 Ventrikeluntersuchungen, die während etwa eines Jahres an der hiesigen Röntgenabteilung vorgenommen wurden, nur viermal um Patienten unter 5 Jahren, und in drei dieser Fälle fand nicht einmal eine vollständige Ventrikeluntersuchung statt, weil es nur darauf ankam, Fremdkörper im Verdauungskanal nachzuweisen. Auch zwischen dem 5. und 18. Lebensjahr waren die untersuchten Fälle spärlich, ihre Anzahl betrug nur etwa 20. Der Umstand, dass — soviel ich feststellen konnte — noch keine kardianahe Magendivertikel bei Röntgenuntersuchung vor der Pubertät angetroffen worden sind, kann also nicht als schlüssiger Beweis für ihre Seltenheit in den Kinderjahren dienen. Wenn man aber auch die Erfahrung der Pathologen berücksichtigt, dass die fraglichen Magendivertikel in der Nähe der Kardia im Kindesalter nicht festgestellt worden sind, so scheint es doch sicher zu sein, dass sie in jüngerem Lebensalter seltener sind als in höherem. Auch ein anderer Umstand kann darauf hindeuten, dass die Magendivertikel in der Nähe der Kardia nicht im eigentlichen Sinne kongenital sind, nämlich die Tatsache, dass sie weit häufiger beim weiblichen als beim männlichen Geschlecht gefunden worden sind. Hierauf hat schon Bernstein hingewiesen. Von 34 Fällen (3 eigene und der Rest aus der Literatur) betrafen 28 das weibliche und 6 das männliche Geschlecht; dies entspricht einem weiblichen Anteil von über 80 %. In Anbetracht der Kleinheit des Materials haben diese Ziffern natürlich nur relativen Wert. Bei den genannten 34 Fällen sind mitgerechnet: Åkerlunds 4 Fälle (weiblich), Briggs' 4 Fälle (weiblich), Bergs 3 Fälle (weibl.), Rencks 2 Fälle (laut persönlicher Mitteilung Frauen), 3 eigene Fälle (davon 2 weibl.), Koppensteins 3 Fälle (darunter 1 weibl.), Fleischners 2 Fälle (davon 1 weibl.) und Emerys 2 Fälle (davon 1 weibl.). Ferner haben folgende 10 Autoren je einen Fall beobachtet (alle ausser einem weiblich): Ravenel, Kalbfleisch, Bernstein, Jonas, Keith, Lawson, Liljedahl, Brandt, Gray und Brückner. Ausserdem haben Duval, Roux und Béclère einen Fall bei einer Frau abgebildet. Dieses starke Überwiegen des weiblichen Geschlechtes erfordert eine Erklärung, und kann man diese finden, so hat man meiner Ansicht nach auch die wichtigste Ursache der fraglichen Divertikel sowohl bei Frauen als bei Männern festgestellt.

Was ist die Ursache für die Prädisposition des weiblichen Geschlechtes zu Magendivertikeln in der Nähe der Kardia?

Noch niemand scheint versucht zu haben, die weibliche Prädisposition zu Magendivertikeln in der Kardiagegend zu erklären. Bernstein,

dem dieselbe aufgefallen ist, sagt, er könne weder eine Erklärung geben noch eine Hypothese aufstellen.

Die fraglichen Divertikel sitzen, wie bemerkt, gewöhnlich dicht unterhalb der Kardia an der hinteren Ventrikelwand. Wenn man dies berücksichtigt und sich meines oben besprochenen Falles erinnert, kann man sich fragen, ob dieselben vielleicht in der Regel bei Magensondierung entstehen. Gehen wir hypothetisch davon aus, dass dies der Fall ist, so müssen wir wegen der grossen weiblichen Prädisposition auch annehmen, entweder, dass bei Frauen viel häufiger Magensondierungen stattfinden als bei Männern, oder, dass ihr Ventrikel infolge anatomischer Verhältnisse leichter durch einen Magenschlauch geschädigt wird als der Ventrikel der Männer. Die erste Voraussetzung trifft nicht zu, denn beide Geschlechter haben ungefähr gleich oft Ventrikelleiden, die eine Untersuchung zur Folge haben. Von 1,000 Ventrikeluntersuchungen auf der hiesigen Röntgenabteilung betrafen ungefähr gleich viele das männliche und das weibliche Geschlecht, jedoch mit einem geringen Überwiegen des ersteren. Die zweite Voraussetzung lässt sich vielleicht nicht ganz von der Hand weisen, da erwachsene Frauen wesentlich häufiger als Männer einen gesenkten Ventrikel von hypotonischer Form haben und es möglich erscheint, dass ein solcher Ventrikel, der bis zu gewissem Grade, vor allem durch die Schwäche der Bauchwand, in der Längsrichtung ausgedehnt ist, leichter durch einen eingeführten Magenschlauch verletzt werden kann als ein männlicher Ventrikel, der in der Regel normo- oder hypertonische Form hat. Verf. glaubt jedoch nicht, dass die Magensonde eine gewöhnliche Ursache der fraglichen Magendivertikel ist; denn wäre dies der Fall, so müsste man erwarten, dass sie weit häufiger wären, als sie es tatsächlich sind. Die Entstehung eines traumatischen Divertikels (durch Magensondierung) erscheint mir indes unter den oben erörterten speziellen Verhältnissen möglich. Man könnte vermuten, dass ein Divertikel mit solcher Genese infolge der namentlich bei gefülltem Ventrikel auftretenden Spannung der Ventrikelschleimhaut rings um die Divertikelmündung bald spontan reponiert wird. Dies ist jedoch vielleicht nicht so sicher, denn in der Kardiagegend sind meines Erachtens bei aufrechter Stellung auch Kräfte wirksam, die teils die Reposition eines ausgebildeten Schleimhautdivertikels erschweren, teils bei lokaler Schwäche oder Beschädigung der Muskelwand danach streben, an dieser Stelle ein solches zu erzeugen. Um zu verstehen, wie diese Kräfte entstehen und wirken, müssen wir uns daran erinnern, wie sich der intraabdominale Druck in dem Teil des Bauches verhält, wo die fraglichen Divertikel liegen.

Der Druck in den verschiedenen Teilen der Bauchhöhle wird bekanntlich vor allem durch den an den betreffenden Stellen herrschenden hydrostatischen Druck bestimmt. Er wird aber bis zu gewissem Grade

auch durch den intrathorakalen Druck und die wechselnden Spannungsverhältnisse beeinflusst, die u. a. während des Atmens am Zwerchfell und an der Bauchwand entstehen. Wenn wir von den Druckvariationen absehen, die auf der Atmung, der Bauchpresse usw. beruhen, wechselt der Druck vor allem mit der Körperstellung. *In der Gegend der Kardia herrscht* bei Rückenlage ein positiver, aber im *Stehen ein negativer intraabdominaler Druck.* Dieser letztere ist es meines Erachtens, der die Divertikelbildung begünstigt. Der negative Druck in dem obersten, intrathorakalen Teil der Bauchhöhle kommt dadurch zustande, dass dieser Teil feste Wände hat und dass die Lungen durch ihre Retraktionskraft im Zusammenwirken mit der muskulösen Bauchwand das Zwerchfell hindern, trotz der Schwere der Baucheingeweide über eine gewisse Grenze zu sinken. Je schlaffer die vordere Bauchwand ist, um so mehr werden die Baucheingeweide das Zwerchfell belasten und senken. Hierbei werden die Lungen stärker ausgedehnt und ihre Retraktionskraft erhöht, was dazu beiträgt, dass wieder eine Gleichgewichtslage für das Diaphragma eintritt. Gleichzeitig mit der Senkung der Baucheingeweide und des Zwerchfells wächst, wie wir sahen, die Retraktionskraft der Lungen, und zugleich sinkt der Druck in den subphrenischen Räumen. Da Frauen, namentlich in und nach dem mittleren Alter gewöhnlich eine schlaffere Bauchwand haben als die Männer und da deshalb das Zwerchfell bei ihnen im Stehen mehr gesenkt ist, können wir den Schluss ziehen, dass bei ihnen der Druck im oberen Teil der Bauchhöhle gewöhnlich niedriger ist als bei den Männern. Hierin liegt meines Erachtens eine wichtige Ursache dafür, dass Frauen mehr zu Magendivertikeln neigen als Männer; denn je niedriger der extraventrikulare Druck ist, umso grösser ist die Gefahr der Entstehung eines Pulsionsdivertikels, wenn der Druck im Ventrikel aus dem einen oder anderen Grunde steigt (hierüber später). Aber auch andere disponierende Momente können vorliegen. So kann jede mit zunehmendem Alter eintretende Schwächung der Tunica muscularis des Ventrikels als ein disponierender Faktor betrachtet werden. Man kann sich daher fragen, ob nicht die Erschlaffung der Bauchwand, die bei älteren Frauen so gewöhnlich ist, indirekt eine solche Schwächung der Tunica muscularis herbeiführt. Wenn die Bauchwand schlaff wird und der gefüllte Ventrikel dadurch seine normale Stütze an den umgebenden Baucheingeweiden verliert, tritt bekanntlich nicht nur eine Ptosis, sondern auch eine Verlängerung des Ventrikels ein, und gleichzeitig werden die kaudalen Ventrikelteile mehr oder minder erweitert. Der Ventrikel nimmt also bei Schlaffheit der Bauchwand eine hypotonische Form an (woraus jedoch nicht zu folgen braucht, dass sein Tonus vermindert ist, wie viele Autoren annehmen). Aus der Ausdehnung der Tunica muscularis, der Stützschicht des Ventrikels, muss begreiflicherweise folgen,

dass dieselbe an schwachen Stellen abnorm hohen Druckdifferenzen zwischen den inneren und äusseren Ventrikelflächen schwächeren Widerstand leistet als vorher, insbesondere, wenn die schwache Stelle infolge ihrer Lage keine Stütze an der Umgebung hat. Solche abnorm hohe Druckdifferenzen entstehen offenbar vor allem, wenn der intraventrikulare Druck gesteigert und gleichzeitig der intraabdominale abnorm niedrig ist. Die gewöhnlichste Ursache einer starken extraventrikularen Drucksenkung (bei aufrechter Stellung) wurde bereits erwähnt: Erschlaffung der Bauchwand. Auch bei starker Abmagerung und vermindertem Bauchinhalt kann im Stehen eine vermehrte Drucksenkung im oberen Teil der Bauchhöhle stattfinden. Die gewöhnlichste Ursache einer intraventrikularen Drucksteigerung ist eine kräftige Kontraktion des gefüllten Ventrikels. Ein noch höherer intraventrikularer Druck als während der Verdauung entsteht bei starker Tätigkeit der Bauchpresse, aber diese Drucksteigerung führt nicht zu den fraglichen Magendivertikeln, weil der Druck ausserhalb und innerhalb des Ventrikels in gleichem Grade steigt. Aber ist das Zwerchfell oder die Bauchwand an irgendeiner Stelle, die an den Ventrikel grenzt, schwach, so kann der erhöhte intraabdominale Druck einen Eingeweidebruch verursachen, in den sich ein Teil der Magenwand divertikelartig vorstülpt. (Hernia umbilicalis, paroesophagea, epigastrica, in cicatrice). Gleichartige Brüche können auch nachträglich auftreten. Diese Brüche werden oft bei geeigneter Körperstellung spontan reponiert, wobei der Ventrikel in der Regel seine normale Form wieder annimmt. In einzelnen Fällen kann der im Bruch liegende divertikelartige Ventrikelteil überdehnt und beschädigt werden, so dass sich ein permanentes Divertikel bildet, was wahrscheinlich vor allem dann der Fall ist, wenn ständig derselbe Teil im Bruch liegt. Chutro beschreibt einen solchen Fall, wo das Magendivertikel den Inhalt eines postoperativen Bauchwandbruches bildete und am Bruchsack adhärierte. Bei den typischen Magendivertikeln dicht unterhalb der Kardia kann es vielleicht bisweilen schwer sein, bei Durchleuchtung im Stehen zu entscheiden, ob sie ganz intraabdominal liegen oder sich durch eine Lücke im Zwerchfell oder in der hinteren Bauchwand vorwölben. Die Untersuchung meiner drei typischen Divertikelfälle hat keine Anhaltspunkte dafür ergeben, dass Bruch vorlag. Untersuchung bei vermehrter Tätigkeit der Bauchpresse (Pressen) fand in zwei der Fälle statt und zeigte keine Vergrösserung des Divertikels. Gegen die Bruchhypothese sprechen auch Koppensteins Beobachtungen, dass typische Magendivertikel bei rechter Seitenlage besser sichtbar werden, weil sie sich dann infolge des Eigengewichtes vom Magen entfernen.

Im gefüllten Ventrikel ist der Druck beim Stehen infolge des hydrostatischen Faktors kaudal am höchsten. Der hydrostatische Druck im

Ventrikel begünstigt jedoch nicht die Entstehung von Magendivertikeln, da er durch einen ungefähr gleichwertigen Druck ausserhalb des Ventrikels kompensiert wird.

Wenn unterhalb der Kardia eine örtliche Schwäche der Tunica muscularis an typischer Stelle besteht, erscheint es natürlich, dass lokale Stösse oder Druck auf den Bauch über dem gefüllten Ventrikel die Entstehung eines Magendivertikels durch Erzeugung einer starken, wenn auch kurzen intraventrikularen Drucksteigerung begünstigen können. *Nach Ansicht des Verf. sind solche zufällige Faktoren von geringer Bedeutung im Vergleich mit dem ständigen extraventrikularen Unterdruck in der Kardiagegend, der im Stehen, vor allem bei schlaffer Bauchwand, vorhanden ist, und mit dem Überdruck im Ventrikel, der auf dessen Tonus und Peristaltik beruht.*

Eine indirekte Stütze für die pathogenetische Bedeutung des extraventrikularen Unterdruckes für Magendivertikel in der Kardiagegend kann man möglicherweise in folgenden Umständen erblicken:

1. Die genannten Divertikel sind im Liegen schwerer zu beobachten als im Stehen (siehe KOPPENSTEIN), was teilweise damit erklärt werden kann, dass der extraventrikulare Unterdruck in der Kardiagegend im Liegen aufhört. (Das Verschwinden des Divertikels bei liegender Stellung in meinem oben besprochenen Fall dürfte jedoch eine andere Erklärung haben.)

2. In einzelnen Fällen hat man röntgenologisch nachgewiesene Magendivertikel bei der Operation erst nach Kompression des Magens (KOPPENSTEINS Fall 3) oder bei der Sektion wiederfinden können (u. a. FLEISCHNERS einer Fall, der bei der Sektion an der Stelle des Divertikels nur eine bei Fingerdruck besonders nachgiebige Stelle aufwies, an der sämtliche Wandschichten atrophisch waren). Dass die Divertikel in den genannten Fällen nicht hervortraten, beruhte offenbar darauf, dass gelegentlich der Untersuchung nicht der Überdruck im Ventrikel bzw. der Unterdruck in der Umgebung herrschte, die notwendig sind, damit sich ein in Entwicklung begriffenes Divertikel ausstülpen kann.

3. Eine dritte Stütze für die Bedeutung des Unterdrucks kann man durch einen Analogieschluss erhalten. Zur Entstehung von Pulsionsdivertikeln am intrathorakalen Teil der Speiseröhre trägt ganz sicher der negative intrathorakale Druck in wesentlichem Grade bei, wenn aus dem einen oder anderen Grunde eine schwache Stelle an der Speiseröhre entstanden ist. Wenn man von Pulsionsdivertikeln spricht, denkt man allerdings — mag es sich nun um den Magen oder um die Speiseröhre handeln — meist an den Überdruck im Lumen, aber tatsächlich ist es natürlich der Grad der Druckdifferenz, welcher den Grad der örtlichen Wandpropulsion bestimmt.

4. Von noch grösserem Interesse scheint mir zu sein, dass auch ZENKERS extrathorakal gelegene Pulsionsdivertikel bis zu gewissem Grade auf dem während eines kurzen Momentes des Schluckens auftretenden negativen Drucke hinter dem laryngealen Teil des Pharynx und dem benachbarten Teil der Speiseröhre zu beruhen scheinen. Um dies verstehen zu können, müssen wir auf gewisse Phasen des Schluckaktes eingehen, die noch nicht völlig geklärt sind.

Einiges über den normalen Schluckakt

Der laryngeale Teil des Pharynx ist bekanntlich vorn eng mit dem Larynx verbunden und macht dessen Bewegungen mit. Im frühen Stadium des Schluckens werden das Os hyoideum und der Larynx zuerst gehoben und unmittelbar darauf nach vorn geschoben. Dies geschieht durch das Zusammenwirken mehrerer Muskeln: M. mylohyoideus, M. geniohyoideus, vorderer Bauch des Digastricus und M. thyreohyoideus. Von diesen hebt der letztgenannte den Larynx gegen das Os hyoideum. Der erstgenannte, der in Bau und Wirkung einem Zwerchfell gleicht, hebt das Os hyoideum und den ganzen Mundboden in kephaler Richtung, wobei er einen erhöhten Druck in der Mundhöhle erzeugt. Die übrigen Muskeln, die vorn am Unterkiefer befestigt sind, ziehen das Os hyoideum und den Larynx nach vorn oder streben, dies zu tun. Dabei streben sie auch danach, den Hypopharynx und den angrenzenden Teil der Speiseröhre zu erweitern, und erzeugen dabei einen Unterdruck in diesen Teilen. Gleichzeitig mit der Drucksenkung in den genannten Pharynx- und Oesophagusteilen tritt natürlich auch eine Drucksenkung im prävertebralen Raum in entsprechender Höhe auf. Hierüber später.

Dass ein negativer Druck (ein »Saugen») im Pharynx und im benachbarten Teil der Speiseröhre während des Schluckens entsteht, hat zuletzt BARCLAY (1930) betont. Seiner Ansicht nach spielt dieses Saugen eine dominierende Rolle für die Nahrungspassage durch den Pharynx und den oberen Teil der Speiseröhre. Seiner Angabe nach hat ANREP gezeigt, dass der negative Druck 16 to 18 inches of water erreicht, when such materials as bread are swallowed. Der Pharynxperistaltik dagegen misst BARCLAY — allerdings mit Unrecht (siehe unten) — normalerweise nur geringe Bedeutung bei (»above the level of the clavicle, apart from abnormal conditions, peristaltis is not seen»). SCHREIBER hat bereits früher (1912) beobachtet, dass im Anfang des Schluckens im Halsteil der Speiseröhre eine Drucksenkung eintritt, die aber im weiteren Verlauf (d. h. nach Eröffnung der Speiseröhre) in eine Drucksteigerung übergeht.

So fand SCHREIBER z. B., dass der Druck in diesem Teil der Speiseröhre zu Beginn — 94 mm H_2O betrug, aber im weiteren Verlauf bis auf

+ 81 mm H_2O stieg (Durchschnitt von 7 Bestimmungen). Bei Vollschlucken waren die entsprechenden Werte — 91 resp. bis + 192 mm. Auch frühere Forscher waren sich klar darüber, dass die Speiseröhre während einer Phase des Schluckens passiv geöffnet wird, und manche haben angenommen, dass dabei auch ein Saugen stattfinden kann. So sagt z. B. EYKMAN (1903): »Die sozusagen passive Erweiterung des Oesophagus durch Nachvorn-rückung des Larynx, woran schon HALLER glaubte, und welche von MAISSIAT wieder hervorgehoben wurde, wurde von SCHIFF an einem Pferde mittels Vivisektion festgestellt. Dass diese Oesophaguserweiterung den Weg für den Bolus freimacht, ist klar; dass sie aber eine saugende Wirkung darauf ausübt, wo kein Luftdruck herrscht, können wir ARLOING nicht zugeben.»

Wenn man genau beobachtet, wie ein Kontrastbissen von flüssiger oder halbflüssiger Konsistenz den Pharynx und den Halsteil der Speiseröhre passiert, muss man sich, wie alle, die sich für diese Phase des Schluckaktes interessiert haben, über die grosse Geschwindigkeit wundern, mit welcher sich der Bissen in diesen Teilen ausbreitet. Nimmt man die Untersuchung nur in aufrechter Stellung vor, so gewinnt man den Eindruck, dass der Bissen herunterfällt, hinabgespritzt oder -gesaugt wird. Dass das Gewicht keine wesentliche Rolle spielt, sieht man jedoch sofort, wenn man den Versuch im Liegen wiederholt. Auch in dieser Stellung sinkt der Bissen sehr rasch, wenn auch nicht ganz so schnell wie bei aufrechter Stellung. KRONECKER und FALK u. a. nehmen an, die energische Kontraktion der Mundhöhlenschliesser — vor allem des M. mylohyoideus — sei die Ursache, dass breiige Speisen und Getränke durch den Rachen und den Oesophagus hindurchgespritzt werden. Sie haben auch im Beginn des Schluckens eine bedeutende Drucksteigerung im Pharynx unterhalb des Gaumensegels — ca. 20 cm Wasser und mehr — nachweisen können. Der von KRONECKER u. a. festgestellte Spritzmechanismus kann jedoch für sich allein nicht das rasche Sinken des Bissens erklären, denn im Augenblick, bevor der Bissen passiert, sind der Hypopharynx und der Halsteil der Speiseröhre geschlossen, wobei Larynx und Trachea dicht an der Wirbelsäule liegen. Diese letzteren Teile müssen sich also von der Wirbelsäule entfernen, damit sich Hypopharynx und Speiseröhre öffnen und füllen können. Dies kann nicht ohne Widerstand geschehen, aber dessen ungeachtet kann man während dieses Momentes des Schluckaktes keine Verlangsamung des Herabsinkens des Kontrastes beobachten. Während des Bruchteils einer Sekunde sinken flüssige und halbflüssige Ingesta von der Zungenwurzel bis zum Jugulum, wobei sie sich in Form einer zusammenhängenden und fast luftleeren Kontrastsäule ausbreiten. Man muss eine wichtige Einzelheit der Röntgenbilder (siehe Fig. 7 u. 8) beachten, die während dieser kurzen Phase des Schluckaktes aufgenom-

men werden, nämlich den Umstand, dass *die in die Speiseröhre hinabdringenden Ingesta in diesem Stadium nicht die Trachea von hinten verengen*, wie sie es notwendigerweise tun würden, wenn die Wegschiebung der Trachea von der Wirbelsäule nur die Folge eines Hinabspritzens

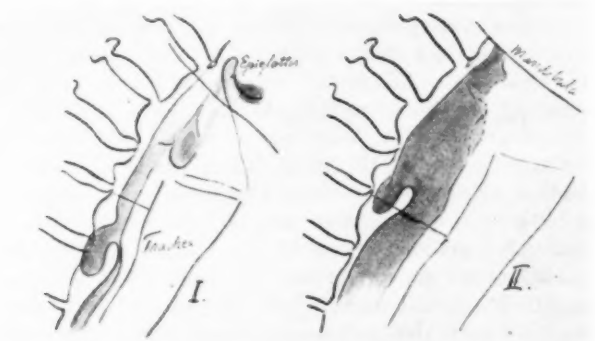


Fig. 7.

I. Das Aussehen nach einen Kontrastschluck. Epiglottis steht vertikal.
II. Im ersten Stadium des Schluckens werden Larynx und Trachea nach vorn und oben gezogen, wobei Hypopharynx und Oesophagus stark erweitert werden. Auch Trachea ist jetzt bedeutend weiter (in sagittaler Richtung) als vorher(!).
III und IV. Larynx immer hoch stehend. Epiglottis steht ungefähr horisontal. Man sieht eine nach unten wandernde Pharynxwelle.

von unter Überdruck stehenden Ingesta wäre. Im Gegenteil sieht man, dass die Trachea in diesem Stadium weiter wird (in sagittaler Richtung) als vor dem Schlucken. Dies kann nicht anders gedeutet werden, als dass das Hinabsinken der Ingesta durch Kontraktion von Muskeln erleichtert wird, die danach streben, Larynx und Trachea von der Wir-

belsäule zu heben und dabei während eines kurzen Augenblickes einen latenten oder manifesten Unterdruck in den entsprechenden Teilen des Verdauungskanals erzeugen. Offenbar war es dieser Unterdruck, den SCHREIBER bereits 1912 manometrisch für den Halsteil der Speiseröhre im Beginn des Schluckens nachweisen konnte. Einen gleichartigen Unterdruck hat Verf. bei Selbstversuchen im Hypopharynx gleichzeitig mit einem Überdruck hinter der Zunge gefunden. Durch die Nase wurden schmale Ureterkatheter, die je mit einem Manometer verbunden waren, eingelegt und in geeignete Tiefe hinabgeschoben. Bei Trinken eines grossen Schluckes Wasser gaben die Manometer Ausschlag; der obere zeigte einen positiven und der untere gleichzeitig einen negativen Druck von ca 5 cm Wasser, der sofort in einen positiven überging; Voraussetzung war dass die Kathetermündungen frei waren.

Auf Serienbildern, die Verf. 1924 von einem Zenkerschen Divertikel aufnahm, konnte man, indem man auf die wechselnde Weite der Trachea achtete, den oben erörterten Unterdruck im Halsteil der Speiseröhre ablesen (siehe Fig. 7 und Tafel 1). Eine Untersuchung desselben Falles 6 Jahre später ergab dasselbe Resultat (Fig. 8).[1] Pat. bekam wiederholt ziemlich dickflüssigen Kontrastbrei, und während des Schluckens wurden Momentbilder (von ca. $^1/_{20}$ Sek.) in der ersten Sekunde, nachdem Pat. das Zeichen zum Schlucken erhalten hatte, aber in verschiedenen Momenten dieser Sekunde aufgenommen. Auf den Platten wurden also bald ein früheres, bald ein etwas späteres Stadium des Schluckaktes festgehalten. Als die Bilder geordnet und mit den während der Durchleuchtung gemachten Beobachtungen über den Schluckakt verglichen wurden, gewann man ein deutliches Bild von dem oben besprochenen »Saugen» im Hypopharynx und im Halsteil der Speiseröhre. Ein Saugen nach diesen Teilen konnte jedoch natürlich nicht den Abtransport des Kontrastes aus ihnen erklären. Aus den Serienbildern ging hervor, dass dieser Abtransport durch eine peristaltische Welle besorgt wird, die im oralen Teil des Pharynx beginnt. Damit ist also BARCLAYS oben erwähnte Ansicht widerlegt, dass die Pharynxperistaltik normalerweise keine Bedeutung für den Nahrungstransport habe.

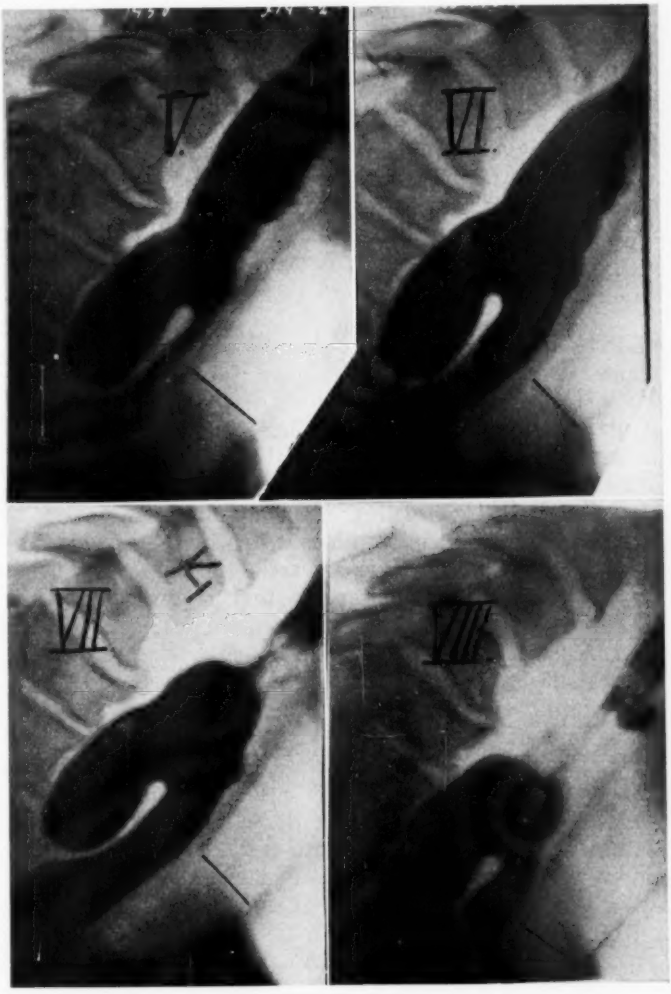
SCHREIBERS Registrierungen der Druckschwankungen im Halsteil der Speiseröhre während des Schluckens und die Wahrnehmungen von KRONECKER u. a. über die Druckverhältnisse im Pharynx ergänzen die von mir gemachten röntgenologischen Beobachtungen. In ihrer Verbindung geben sie ein Bild der ersten Schluckphase, das sich in wesentlichen Punkten von der herrschenden Lehre unterscheidet. Zusammenfassend kann man sagen, dass sich der Kontrastbissen, wenn er flüssig ist, rasch — während des Bruchteils einer Sekunde — als ein zusammenhängender Strang im Pharynx und im Halsteil der Speiseröhre ausbrei-

[1] Das Divertikel war indessen viel grösser geworden.

Fig. 8. Acht Phasen des Schluckaktes während

I. Nach Schlucken ist das Divertikel noch gefüllt; es verengt die Trachea von hinten.

II—V. Das Divertikel ist mit Larynx und Trachea in die Höhe gestiegen und wird nach und nach stärker gefüllt — *Stadium des Spritz- und Saugmechanismus.* Trachea erweitert(?).



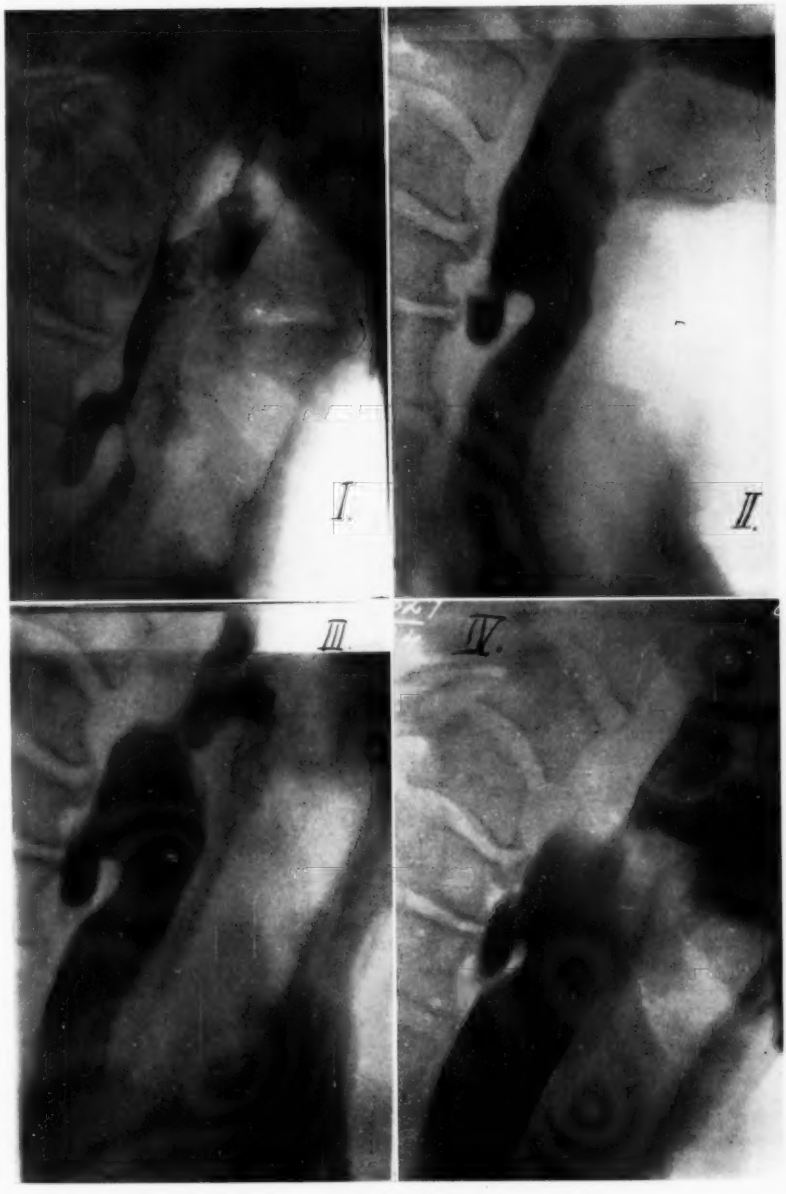
der ersten Sekunde nach Kommando: Schlucken!

VI—VIII zeigen die wandernde Kontraktionswelle im Pharynx, die die Kontrastmasse nach unten presst, wobei der vor dem Divertikel liegende Teil des Oesophagus stärker gefüllt wird. Dabei wird die Trachea in Divertikelhöhe von hinten verengt — *Die peristaltische Phase.*

Quer über die Trachea sind in Divertikelhöhe Linien eingezeichnet, die die Weite des Lumens zeigen.

tet. Dieses rasche Hinabgleiten beruht darauf, dass gleichzeitig ein Überdruck im Buccopharynx und ein Unterdruck im Hypopharynx und im Halsteil der Speiseröhre entsteht. Wenn sich die letzteren Teile mehr und mehr füllen, steigt der Druck hier, wie SCHREIBER gezeigt hat, in zwei Etappen und wird rasch positiv. SCHREIBER fand nämlich bei Vollschluck zu Beginn i. D. — 68 mm H_2O, nach Eröffnung der Speiseröhre bis + 88 und weiter bis + 170 mm H_2O. Die erste Drucksteigerung beruht ganz sicher auf dem raschen Hinabspritzen der Nahrung aus dem Buccopharynx in die Speiseröhre, wobei diese mehr und mehr gefüllt wird, die zweite stärkere Drucksteigerung dagegen auf der rasch folgenden, röntgenologisch sichtbaren peristaltischen Welle im Pharynx.

Ein näheres Eingehen auf die Schluckmechanik liegt abseits meines Hauptthemas. Das Gesagte möge genügen, um zu zeigen, dass die Differenz, die während einer kurzen Phase des Schluckens zwischen dem Druck in und ausserhalb der Speiseröhre entsteht, in Verbindung mit einem anatomischen Locus minoris resistentiae am Übergang zwischen Hypopharynx und Speiseröhre die Entstehung der Zenkerschen »Pulsionsdivertikel» begünstigen kann. Der negative prävertebrale Druck, der eintritt, wenn die Trachea während des Schluckens nach vorn gehoben wird, kann natürlich die Divertikelbildung nicht begünstigen, solange der Druck auch in Speiseröhre und Hypopharynx negativ ist, sondern erst während einer späteren Phase, wenn der Druck hier infolge reichlicherer Anhäufung der aus dem Buccopharynx herabgepressten Kontenta positiv geworden ist. Wenn der Druck positiv wird, ist der Druck prävertebral anfangs noch immer negativ infolge der Kräfte, die den Larynx und die Trachea und mit ihnen die Speiseröhre nach vorn heben. Man kann, wenn ein kleines Divertikel vorliegt, sehen, wie sich dieses bereits füllt, wenn der erste Kontrastbissen die Divertikelöffnung passiert. Der Kontraststrom teilt sich dann an der Divertikelmündung in zwei Ströme, von denen der grössere seinen Weg in die Speiseröhre hinab nimmt (Fig. 7, II). Bei grossem Divertikel dagegen ist die Passage durch den vor dem Divertikel liegenden Teil der Speiseröhre eng (Fig. 8), und dieser Teil erweitert sich relativ stark erst, wenn der Druck des Bissens unter dem Einfluss der kräftigen Pharynxperistaltik eine gewisse Höhe erreicht hat. Diese Peristaltik presst so reichlich Kontrast am Divertikel vorbei, dass die Speiseröhre hier anschwillt und die Trachea von hinten verengt (Fig. 8, VI—VIII). Hierbei dürfte auch der prävertebrale Druck in Divertikelhöhe positiv werden. In solchen Fällen spielt vielleicht der Überdruck im Divertikel die wesentlichste Rolle für dessen Zunahme. *Für die Entstehung eines Divertikels wiederum scheint mir der negative Druck hinter der Speiseröhre eine wichtige Voraussetzung zu sein.* Denn die hintere Hypopharynx- und Oesophaguswand



Tafel I.

hat, wenn die Speiseröhre nicht nach vorn gehoben wird, eine so feste Stütze an der Wirbelsäule, dass ein Divertikel nicht lediglich durch einen Überdruck im Hypopharynx entstehen könnte.

ZUSAMMENFASSUNG

Ein Fall von *passagerem Magendivertikel in der Kardiagegend* wird beschrieben, und die *Ursachen der daselbst gelegenen Divertikel* werden erörtert. Dieselben werden in der Regel im mittleren Lebensalter und später, meist bei Frauen (28 von 34 Fällen), angetroffen. Verf. glaubt, dass sie meist »Pulsionsdivertikel» sind, und gelegentlich traumatische Genese haben können. Als mitwirkende Ursache solcher »Pulsionsdivertikel» wird der intraabdominale Unterdruck hervorgehoben, der im oberen Teil des Bauches bei aufrechter Stellung eintritt und nach Ansicht des Verf. bei Frauen mit schlaffer Bauchwand ausgesprochener ist als bei Männern. Hierin erblickt Verf. eine Ursache für die Prädisposition des weiblichen Geschlechtes.

Die Entstehung der *Zenkerschen Oesophagusdivertikel* wird nach Ansicht des Verf. durch den Unterdruck begünstigt, der retro-oesophageal während einer kurzen Phase des Schluckens herrscht, wenn das Divertikel sich zu füllen beginnt.

Der *buccopharyngeale Schluckakt* wird besprochen: die rasche Passage des Bissens durch den Pharynx beruht auf einem kombinierten Druck- und Saugmechanismus, in zweiter Linie auf der Peristaltik des Pharynx.

SUMMARY

The author describes a case of *transient diverticulum of the stomach*, in the region of the cardia, and discusses *the causes leading to the formation of diverticula at that point*. They are mostly found in middle-aged or older, and oftenest in women (28 cases out of 34). In some cases their origin may be traumatic; the author believes them to be mostly »pulsion diverticula», and an essential factor in the formation of the latter he sees in the intra-abdominal downward pressure which takes place in the upper part of the abdomen when the body is in an upright position. This diminution of pressure, in his opinion, is more pronounced in women with a slack abdominal wall than in men and would thus account for the greater liability of the former to this particular form of diverticulum.

As regards *Zenker's diverticulum of the esophagus*, the author believes its formation to be to a certain extent promoted by the downward pressure exerted at the back of the esophagus during a short period of the swallowing process, when the diverticulum begins to fill.

Also the *bucco-pharyngeal phase of deglutition* is mentioned. The rapid passage of the mouthful through the pharynx depends upon a combined mechanism of pressure and suction, in the second place on the peristalsis of the pharynx.

RÉSUMÉ

L'auteur décrit un cas de *diverticule stomacal passager siégeant dans la région du cardia* et discute *l'étiologie des diverticules de cette région*. En règle générale, ceux-ci apparaissent vers l'âge moyen et plus tard; ils sont plus fréquents chez la femme (28 cas sur 34). L'auteur pense que ce sont en majeure partie des »diverticules

de pression», et qu'ils peuvent, dans certains cas, avoir une origine traumatique. Comme cause adjuvante de ces diverticules de pression, l'auteur signale la chute de pression qui se produit dans la partie supérieure de l'abdomen, dans la station verticale; à son avis cette chute de pression est plus marquée chez les femmes à paroi abdominale lâche que chez les hommes, ce qui explique la prédisposition du sexe féminin à cette affection.

Le diverticule oesophagien de Zenker serait, suivant l'auteur, favorisé par la dépression qui se produit dans la région rétro-oesophagienne pendant une courte phase de la déglutition, au moment où le diverticule commence à se remplir.

L'auteur commente le mécanisme de la déglutition bucco-pharyngale: le passage rapide du bol alimentaire à travers le pharynx dépend d'un double mécanisme de pression et d'aspiration, et, en second lieu, du péristaltisme du pharynx.

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UN APPAREIL SPÉCIAL POUR L'EXAMEN RADIOGRAPHIQUE DU THORAX[1]

Communication au 3ième Congrès international de radiologie.
Paris, juillet 1931

Par

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Röntgenlaboratorium der N. V. Philips' Gloeilampenfabrieken.

Les conditions pour obtenir le maximum de contraste et de netteté d'image avec les radiographies instantanées ont été publiées dans le numéro 66 de ce journal[2]. Le principe d'un appareil y était annoncé pour réaliser ces conditions en utilisant le tube à anode tournante.

Ce tube (fig. 1) peut supporter une charge instantanée huit fois supérieure à celle d'un tube à anticathode fixe de foyer équivalent.[3] Il permet de faire des téléradiographies très contrastées, même à rayons très mous[4] avec un foyer de 1.5 mm de diamètre en quelques centièmes de seconde seulement. Il en résulte que la netteté de l'image des tissus mous du poumon, toujours en mouvement par suite des pulsations du cœur, peut être considérablement augmentée, de sorte que l'on peut par exemple discerner plus tôt les lésions tuberculeuses.

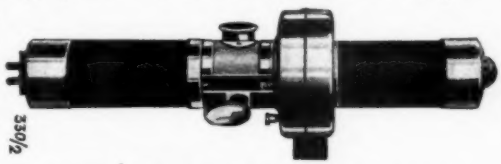

Fig. 1. Tube Rotalix à anticathode tournante.

Quoique ceci signifie un progrès sérieux dans le diagnostic pulmonaire, l'emploi de ce tube a été limité jusqu'à présent à un petit nombre de docteurs qui disposaient d'un appareillage très puissant, p. e. triphasé, sur une ligne d'alimentation de section considérable.

Les secteurs monophasés ou continus ne peuvent donner le maximum de rendement de ce tube et en général ils ne peuvent fournir *l'intensité de courant* voulue sans une chute de tension prohibitive. Pourtant la

[1] Remis à la Rédaction le 19 Sept. 1931.

[2] A. Bouwers, Acta Radiologica XII, 175, 1931.

[3] A. Bouwers, Fortschr. a. d. Geb. d. Röntgenstr., Kongressheft 1929.

[4] H. Chantraine et P. Schulte-Tigges, Beiträge zur Klinik der Tuberkulose 73, 117, 1929.

quantité d'électricité nécessaire pour une téléradiographie du thorax n'est pas énorme, même quand on utilise des rayons très mous.

Or, si l'on tire cette énergie d'un condensateur chargé au préalable, on peut disposer d'un courant très fort et par conséquent d'un temps de pose très court, sans avoir besoin d'une forte ligne d'alimentation, parce que, du fait que l'on peut charger un condensateur pendant un temps relativement long, soit quelques dizaines de seconde par exemple, le courant pris préalablement au secteur peut être très faible.

Fig. 2. Appareil Rotalix.

Pour mettre le tube à anode tournante à la portée de chaque centre de radiologie pulmonaire, quelle que soit sa source d'énergie, un appareil est réalisé d'après ce principe et adapté spécialement à l'utilisation de ce tube (fig. 2). Cet appareil contient un condensateur de grande capacité et d'un encombrement très réduit, qui est chargé à travers une soupape par un transformateur haute tension. Au moment de la prise du

cliché, le condensateur se décharge à travers le tube à l'aide d'un relai électromagnétique qui courtcircuite une espèce de spintermètre à boules qui sépare le tube du condensateur (fig. 3).

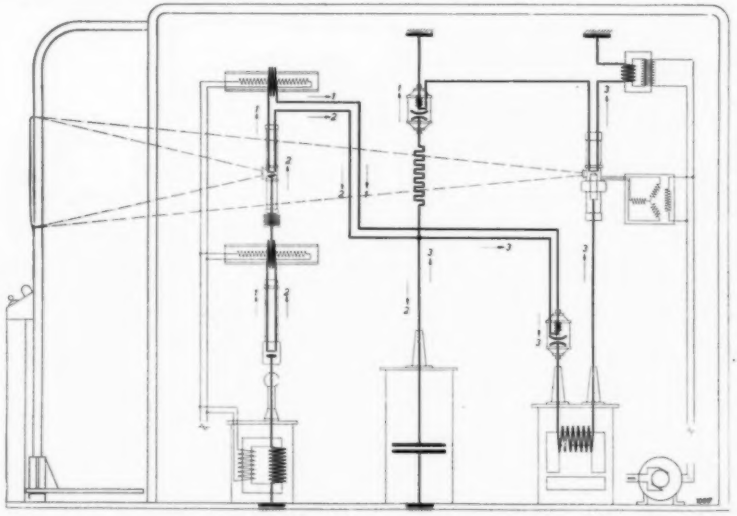

Fig. 3. Schéma du circuit haute tension.
1. radioscopie. 2. charge. 3. décharge (radiographie).

Montée en série avec le tube, se trouve une self de grande impédance qui est essentielle pour obtenir un rendement maximum du tube. Ainsi que la théorie le prouve, une telle self joue un rôle important dans le circuit de décharge du condensateur, pourvu qu'elle soit d'une grandeur appropriée[1]. La figure 4 montre l'effet de la self de grande impédance utilisée dans cet appareil. La courbe *a* représente la décharge d'un condensateur sans self; on voit que la tension diminue très fort dans les premières centièmes de seconde et ainsi le tube recevrait un choc initial d'une tension beaucoup plus élevée que la tension moyenne de la radio. La courbe *b* montre l'influence de la self et l'on voit que lorsque les valeurs sont bien choisies la tension

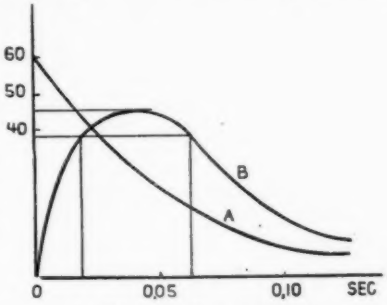

Fig. 4. Décharge d'un condensateur:
a) sans self, b) avec self.

[1] A. Bouwers, Fortschr. a. d. Geb. d. Röntgenstr. Kongressheft 1931.

est pratiquement constante pendant le temps de pose. Seulement la self ne sert pas en premier lieu pour supprimer le choc et les oscillations initiaux[1], mais elle a été prévue spécialement pour transformer le cours de la décharge, d'origine très dévaforable, de manière à obtenir une tension pratiquement constante, qui comporte des contrastes plus grands qu'on ne peut réaliser autrement.

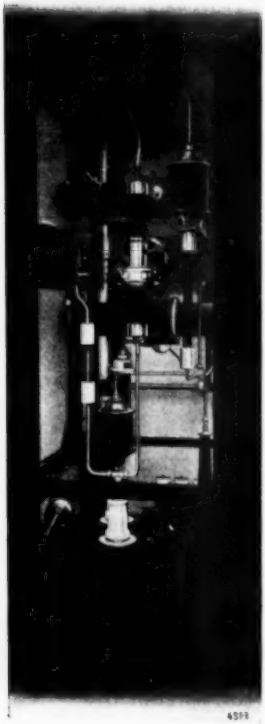

Fig. 5. Intérieur.

1. Interrupteur général.
2. Correction de la tension du secteur.
3. Voltmètre.
4. Lampe témoin à néon.
5. Manette pour monter et descendre la plate-forme.
6. Réglage de la tension d'utilisation.
7. Eclairage.
8. Milliampéremètre.

Fig. 6. Pupitre de commande.

La figure 5 montre l'intérieur de l'appareil. On voit le bac de la self cachant complètement le transformateur dont les dimensions ne sont que légèrement plus grandes que celles de l'appareil »Metalix» portatif.

En prenant une faible tension primaire pour les radiographies d'enfants, et des tensions de plus en plus élevées pour des sujets de plus en plus forts, on aura des contrastes de même aspect pour pratiquement toutes les gammes d'épaisseurs de malades, tandis que le temps de pose sera tonjours du même ordre (0.03 à 0.05 seconde) pour un noircissement habituel du film.

[1] POHLMAN, Fortschr. a. d. Geb. d. Röntgenstr. Kongressheft 1931.

Le tube »Rotalix» est placé à l'intérieur d'une armoire métallique qui contient tous les éléments de haute tension nécessaires. Il est immobilisé à une distance de 1.50 m du porte-cassette monté derrière l'écran fluorescent fixé à l'extérieur. Pour centrer on place simplement le malade

Fig. 7. L'appareil en service.

devant le milieu de l'écran et on l'amène à la hauteur voulue à l'aide de la plate-forme munie d'un mouvement ascensionnel et actionnée par un moteur électrique. Cette méthode est beaucoup plus pratique que celle appliquée d'ordinaire où l'on laisse le malade en place et où l'on centre ensuite la cassette et le tube l'un après l'autre.

Un deuxième tube à foyer très fin, prévu exclusivement pour la radioscopie, se trouve également dans l'armoire. On peut le déplacer à l'aide d'un levier de commande sortant de l'armoire et portant en même temps les manettes du diaphragme. En tirant ce tube de sa place

de repos, il est automatiquement mis au régime de scopie et à la tension choisie d'avance et réglable à volonté. En poussant ce levier de côté après l'examen, le courant est coupé et le champ est libre pour les rayons du tube de radiographie fixé à l'extrémité de l'armoire à une plus grande distance anticathode-plaque. En pressant un petit interrupteur à main

Fig. 8. L'appareil en service.

d'une seule opération on charge le condensateur, on met en route l'anticathode tournante et l'on allume le chauffage du tube »Rotalix»; en repoussant le même interrupteur on fait la radiographie, on arrête le chauffage et la rotation de l'anticathode. La figure 6 montre le pupitre de commande avec la place protégée pour les cassettes chargées. Les fig. 7 et 8 montrent l'appareil en service avec des malades de diverses grandeurs. Les yeux du médecin se trouvent toujours à la même hauteur par rapport à l'écran fixe tandis que le malade est monté ou descendu à volonté.

En plus de l'autoprotection des tubes, toutes les mesures sont prises pour protéger l'opérateur contre les rayons secondaires. L'ensemble constitue donc une installation de grande puissance et sûre, pour examen du thorax, et qui peut être branchée sur tous secteurs d'éclairage. L'encombrement total est de 80 × 200 cm.

RÉSUMÉ

L'auteur décrit un appareil pour le radiodiagnostic thoracique construit spécialement pour l'utilisation du tube à anode rotative.

L'énergie électrique nécessaire pour la radiographie est accumulée préalablement dans un condensateur qui est déchargé dans le tube Rotalix à travers une grande self. Par cette dernière la tension est rendue pratiquement constante pendant la prise de la radiographie de sorte que le tube est chargé sous conditions maximales et une netteté d'image est obtenue autrement irréalisable, même pour les radiographies à rayons très mous.

L'ensemble constitue une installation ultra-puissante pour l'examen thoracique, à protection intégrale et à simple manipulation. Elle peut être branchée sur tout secteur voulu, même à faible puissance.

L'encombrement total est de 80 × 200 cm.

ZUSAMMENFASSUNG

Verfasser beschreibt einen Apparat für Thoraxdiagnostik, der speziell für die Benutzung der Drehanodenröhre gebaut ist.

Die für die Aufnahme benötigte elektrische Energie wird vorher in einem Kondensator gesammelt, welcher durch die Rotalix-Röhre über eine grosse Drosselspule entladen wird. Durch diese letztere wird die Spannung während der Aufnahme praktisch konstant gehalten, sodass die Röhre unter optimalen Bedingungen benutzt wird und eine sonst nicht erreichbare Bildschärfe erzielt wird, sogar bei ganz weichen Aufnahmen.

Der Apparat stellt einen kompletten Arbeitsplatz für Thoraxuntersuchung dar, hochspannungs- und strahlensicher und sehr einfach zu handhaben, der auf ein jedes, auch schwaches Netz angeschlossen werden kann.

Der Raumbedarf beträgt 80 × 200 cm.

SUMMARY

The author describes an apparatus for the diagnosis of the chest and lungs, specially constructed for use with a tube with rotating anode.

Prior to the exposure the electrical energy necessary for the radiograph is stored in the condensor which is discharged through the rotalix-tube via a large inductance. The latter ensures that the tension during the exposure is practically constant. The tube is therefore used under the most favourable conditions. An otherwise unattainable sharpness of definition is thus acquired, even with radiographs produced with low kilovoltages.

The whole forms a complete shockproof and x-ray protected installation, easy to manipulate, and can be connected to every main supply, even of small capacity.

The occupied space is 80 × 200 cm (approximately $2^1/_2 \times 6^1/_2$ feet).

THE RADIUM STATION OF COPENHAGEN

Its Purpose and Organization[1]

by

Jens Juul

On March 4, 1931, the new and enlarged Radium Station of Copenhagen was inaugurated. This signifies a great progress in the outer conditions under which the radium treatment is carried out in Denmark; and by the affiliation of the Radium Station with the Finsen Institute there is now in Copenhagen a radiotherapeutic institute that may presumably be said to be quite unique of its kind. It is only natural that this institute was established in the city where NIELS FINSEN lived and worked. By the affiliation of the Radium Station with the institute bearing Finsen's name, all forms of radiotherapy have now been assembled in this place.

History of the Radium Station

The first step to organize the combating of cancer in Denmark was taken in 1905, when the Cancer Committee of the Danish Medical Association was founded — with JOHANNES FIBIGER for president a good many years. The activities of the Cancer Committee were of several sorts; amongst other tasks, it kept in touch with similar committees abroad, it carried out some comprehensive statistical studies, and it established various stations for free histological examination of tissues from patients suspected of cancer.

The next great advance was made in 1912, when the Radium Foundation was established — a foundation with »the purpose of rendering aid to the treatment of cancer and cancer-like diseases, primarily by providing the means for the treatment of these diseases with radium». The foundation was established to the memory of King Frederik VIII, and H. M. King Christian X assumed its protectorate. Through the daily press and by contributions from public and private institutions, a collection was made of ca. 110,000 Danish crowns; and on November 2, 1912,

[1] Submitted for publication Aug. 21st. 1931.

the first shipment of the purchased radium — a total of 125 mgm. — was received. Through additional contributions in the subsequent years, the stock of radium was gradually increased. Yet, in 1921, there was, all told, only ca. 400 mgm. of radium in Denmark. As this scarcity of radium was pinching, the Radium Foundation took up a new national collection, in 1921, which yielded more than $1^1/_2$ million Danish crowns, beside a State grant of aid amounting to $^1/_2$ million crowns. For this money $1^3/_4$ gm. of radium was purchased.

By these purchases of radium, then, the Radium Foundation made radium treatment obtainable to a steadily increasing number of cancer patients in Denmark; and at the same time the foundation did some great work to ensure that this radium treatment might be given under the safest conditions possible. Thus, in 1913, a radium station was established in Copenhagen; and in 1914, radium stations were established in two provincial towns, Aarhus and Odense. All the three stations were chiefly intended for ambulatory treatment, only a few beds being available. Patients who had to stay in hospital in order to be treated effectively, were largely referred to the general hospitals, and then the radium was lent to these hospitals.

As the radium treatment was being adopted more and more, and as favourable results from the radium treatment were reported from abroad in a steadily increasing number, it was obvious that better conditions for the treatment had to be brought about if the radium was to be utilized fully. In the case of Copenhagen this question was solved, in 1922, by renting a house — located on the grounds of the Finsen Institute — where the working conditions were far better than before, and in which there was room for 23 beds. In this radium station some great work has been carried out during the past nine years. The station has been directly under the charge of the Radium Foundation, and thus it has been independent of of the Finsen Institute as far as its administration is concerned.

Now the conditions attained were fairly satisfactory as to the stock of radium in hand as well as to the therapeutic arrangement. Still, with the improvement of the radium therapy and under the impression of the steadily increasing cancer mortality in Denmark, it was subsequently decided to extend this work on a broader basis.

To this purpose, in 1928, the Cancer Committee of the Danish Medical Association was united with the Radium Foundation, forming the Danish Cancer Committee. Under the auspices of this committee was founded the »National Anti-Cancer Association», which in a short time had a membership of about 44,000; and thus the yearly subscription of the members gave the funds for the work. Then, in 1929, it was decided again to organize a national collection; and this yielded 1.2 million Danish

crowns. To this were added a State grant of 125,000 crowns, a contribution of 250,000 crowns from the Danish life insurance companies, and numerous donations from private persons.

Thus the preparations were made and ready for a new advance, that began with the purchase of ca. 4 gm. radium, so that now the National Anti-Cancer Association has at its disposal a total of about 6 gm. of radium. Beside supporting the scientific cancer research and conducting educational work amongst the population, the National Association made it one of its main tasks to extend and improve the three Radium Stations. With the completed extension of the Radium Station of Copenhagen, the first part of this task has been worked out.

From what has been said above, it is evident that the Radium Station of Copenhagen is a private institution; it is managed by the National Anti-Cancer Association, with a State grant of aid. The administration of the old radium station was also independent of the Finsen Institute, whereas the present Radium Station and the Finsen Institute have been united administratively under the same board of directors. Each of these two institutions has its own economical independence, and the budget of the Radium Station has to be endorsed by the directors of the National Association.

Purpose of the Radium Station

Radiation treatment of malignant tumors is the task on which the work is to be concentrated above all. But all other lesions, too, in which radium treatment may be applicable, are treated in the Radium Station. So the Radium Station is not precisely a cancer hospital but a centre for radium treatment — what is considered most desirable on the score of the patients and the fear of cancer.

With a few exceptions, all radium treatment given with the radium purchased by the National Association is to be given in one of the three radium stations. Still, a few hospitals are entitled to order emanation for own use from the laboratory of the Radium Station of Copenhagen. Such orders are filled only on special permission from the directors of the National Association, particular stress being laid upon the point, that the emanation is furnished only to physicians who have been trained especially in radium treatment. In Denmark, then, the radium treatment is mainly centralized in these three stations, one in each of the three main parts of the country — largely after the plan that has led the radium treatment in Sweden to such a high standard. Roentgen-ray treatment of malignant tumors,on the other hand, is still being given in a good many of the hospitals throughout the country. In all probability, the

Roentgen-ray treatment ought to be more centralized too; and in certain fields this is absolutely desirable — namely, in the non-infrequent cases where there are indications for a combination of various forms of radiotherapy with or without surgical treatment. In these cases it is very important that the plan of treatment is fully settled from the very start, and the different measures of treatment are not carried out by different physicians without any cooperation.

To make practicable this combination of treatment, the Radium Station comprises departments for Roentgen-ray treatment as well as for radiumtherapy. As the radiotherapy is the main field of work, it has been decided that the management of the station is to be under the charge of a physician with special radiological training. But, to make practicable the combination of surgical measures with radiotherapy in the station, a surgeon — who is also gynecologist — has been appointed on the staff of the station. Furthermore, in the station there is ready access to special oto-laryngeal treatment and to special treatment within the fields of dermatology, ophthalmology and internal medicine, as the chief physicians and specialists of the Finsen Institute are acting as consulting physicians to the Radium Station.

As the treatment is given both to out-patients and to patients admitted to the hospital, the station comprises a hospital department and a dispensary. The chief physician with radiological training is also in charge of the hospital department. It has been insisted upon that the radiologist should have the best opportunity possible to examine the patients and to plan out their treatment. Thus, here the radiotherapy is recognized as a particular branch of medicine, on a level with the other specialities.

As it is fully realized how important it is — especially in such a young discipline as radiotherapy — to be able to follow the patients for several years after their treatment, the organization of the office and registration work has provided for that no patient is lost sight of as long as information of his condition is thought to be of significance to the scientific value of the material. All the patients will be requested, as far as possible, to appear for after-examination. In cases where this is impossible the station will keep advised of their condition by correspondence with the patients themselves or with their physicians. The relatively small acreage of the country is a very valuable factor in this respect. The travelling expenses are relatively small; yet they are playing a non-inconsiderable rôle in some instances. Thanks to a couple of legacies several patients may be helped in this respect, but it is obvious how valuable it would be to the clinical scientific work if the patients were granted a costfree journey to and from the Radium Station — just as is done in Sweden.

Fig. 1. The Radium Station of Copenhagen, facing South.

The clinical work in the field of radiotherapy is the main task of the Radium Station. But it is one purpose of the Radium Station, too, to take part in the experimental cancer research and radiological investigation. For that purpose, various laboratories have been arranged in the Radium Station itself. In addition, a laboratory for experimental studies has been built and arranged in connection with the laboratory of the Finsen Institute, which has also recently been extended on a large scale.

Arrangement and Organization

The *building* of the Radium Station consists in a wing of an older date and a new addition — what is sufficiently clear from its outer views. In architectural respect this building represents a bold experiment in combining a wing in modern style of building — after functionalistic principles that offer particular advantages to a hospital — with a monumental building in quite a different style, of an older date. The old wing was built about 20 years ago, for the medical department of the Finsen Institute. It has now been altered and arranged for its special purpose, and it serves as the hospital department of the Radium Station beside containing the living quarters for a large part of the personnel. In the new wing are located the office, rooms for the consultation of out-pati-

ents, for radium treatment and for Roentgen-ray treatment, operating room, and physical and pathological laboratories.

The *Hospital Department* is equipped with beds for 50 patients. There is one large ward with 10 beds, and 3 smaller wards, each with 5 beds. For the rest there are small rooms, each with 1, 2 or 3 beds. These wards and sick-rooms occupy the first and second stories of the building; and, in addition, each story has a parlour for the patients. The second story is equipped with a large balcony. The Department is further provided with a clinical laboratory and a physician's room. In the third (top) story are the bath-rooms, and besides the living-rooms for the nurses and the interne. In the lofty basement are rooms for the maids. The furnace-room, of course, is located here too; and so are the animal rooms.

The *Out-patient Department* has waiting-rooms and 3 consultation-rooms — one for the chief physician (radiologist), one for the surgeon, and one for the assistant physicians. In connection with the consultation-room of the surgeon there is an examination-room equipped especially for gynecological examination, cystoscopy, rectoscopy and other such methods of examination; and all the consultation-rooms are connected with cabins for change of clothes. These rooms are all located in the first story of the new wing, where is also the office, so that every patient has to pass through the office before he is examined or treated.

The *radium applications* are performed in the consultation-rooms before and after the consultation hours (which are 10—12) or, in the case of difficult applications and punctures, in the operating-room in the second story.

Of solid radium, for the present the station has at its disposal a total amount of 1642 mgm., distributed in tubes, needles, and flat applicators of various sizes. If sometimes this is not enough, use is made of emanation, produced in the physical laboratories by means of 2 gm. radium in solution. Emanation in capillaries of gold is also employed for punctures.

The radium preparations are kept in the second story — in a box, locked up in a safe, and surrounded throughout by ca 5 cm. lead. The safe with the box is placed in a corner of the room employed for packing of radium.

The *operating-room*, which is used only for minor operations, electrocoagulation and difficult applications of radium, is located in the second story, in connection with the packing room. Major operations on the patients of the Radium Station are performed in the operating-rooms of the surgical department of the Finsen Institute. The operating-room of the station is situated so that there is ready access to it from the hospital department of the station.

The *Roentgen-ray department* is also located in the second story of the new wing, readily accessible from the out-patient department as well as from the hospital department. Here are two treatment rooms, with one

Fig. 2. The Radium Station of Copenhagen, facing East.

service room in common. For the present this department has two Stabilivolt apparatus, one of these equipped for two-tube application. One apparatus is equipped with a »cannon» of the Wintz type, the other with two Holfelder's »cannons» of the latest type.

For measuring apparatus the station has one »Küstner's Eichstandgerät» and one Baastrup-Johnsen dosimeter. Once a week — and oftener if considered necessary — the capacity of the Roentgen-ray apparatus is controlled by the physicists of the station, through measuring with the Küstner apparatus. If one wishes to ascertain the dose during the treatment, this is done with the Baastrup-Johnsen dosimeter.

The *pathologic-anatomical laboratory* is located in the lofty, airy and light basement story. Here, too, are the *physical laboratories*, arranged and equipped for measurings and for scientific investigations, besides for the production of emanation. Here 2 gm. of radium — in solution — is kept in a box.

The Laboratory for Experimental Research is located in a new building, which it shares with the Research Laboratory of the Finsen Institute.

Personnel: The medical staff consists of a Chief Physician (with special radiological training), who is appointed the leader of the clinical and experimental work. For the assistance of him and the other physicians is appointed an Assistant Physician (appointed for up to 5 years) and an Interne (appointed for up to one year) who has living quarters in the station. The Chief Surgeon of the Finsen Institute is appointed surgeon and gynecologist to the Radium Station. He holds daily consultation in the station, and he examines and treats all the cases of cancer of the uterus; besides, he performs the more extensive electrocoagulations and operations. In cases where it is a question of a combination of surgical and radiological treatment, the treatment is planned out by the chief surgeon and the radiological chief physician together. The other chief physicians and specialists of the Finsen Institute are acting as consulting physicians to the Radium Station, so that the station has ready access to specialist consultation in dermatology, oto-laryngology, ophthalmology and medical diseases. The staff further includes a pathologist who has the charge of the pathologic-anatomical laboratory and makes the histological examinations.

To the station is appointed one physicist with two assistants. They take care of the emanation production and make the glass and gold capillaries containing the emanation; besides, they carry out all the measurings of the radium preparations and control the Roentgen-ray apparatus. In questions of physical nature, they assist the physicians with their advice, and they are further engaged in scientific investigations in the field of radiation research.

Fig. 3. The Radium Station of Copenhagen. Plan of 1st story.

I. One bed room. II. Two-bed room. X. Ten-bed room.
D. Patients' sitting-room. K. Kitchen. L. clinical laboratory. V. Nurses' dining-room.
1. Office. 2. Waiting-room. 3. Consultation room. 4. Examination room. 5. Record room.

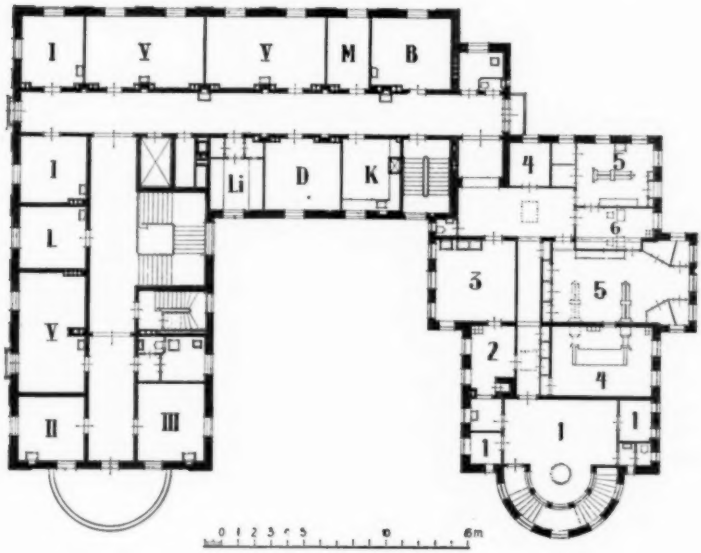

Fig. 4. The Radium Station of Copenhagen. Plan of 2nd story.

I. One-bed room. II. Two-bed room. III. Three-bed room. V. Five-bed room.
B. Wash-room. D. Patients' sitting-room. L. Physician's room. Li. Linnen room. M. One-bed room.
1. Waiting-room and rooms for ambulant patients. 2. Packing-room. 3. Operating-room.
4. Roentgen-machines. 5. Roentgen-treatment room. 6. Service room.

The nursing personnel is under the charge of a head nurse. The hospital department has 6 assistant nurses, while the out-patient department has 1 head nurse and 1 assistant nurse. In addition, the agreement has been made with the Finsen Institute that every day a nurse from this institute spends some hours in the Radium Station where she is occupied — under the direction of the head nurse — with the packing of the radium. Each packer serves only 3 months in this capacity, and she does never return to this kind of work till several years have passed, and in this interval she will never have anything to do with radium.

The Roentgen-ray apparatus are operated by 2 Roenten-ray assistants (working 7 hours a day). The operation of the Roentgen-ray apparatus required by both treatment rooms is carried out in a common service room, of which the walls are covered with plates of lead. As further the tubes are encased in ray-proof »cannons» and placed so that no direct radiation can reach the walls of the service room, the protection against the radiation is very effective. The consultation and examination rooms are located under the Roentgen-ray department; through the entire floor is a layer of lead 3 mm. in thickness.

The office work is carried out by a cashier and a secretary who, besides, are assisting in controlling the patients. The accountancy takes place in the joint head-office of the Finsen Institute and the Radium Station. Fees are paid separately for consultation, radium treatment, Roentgen-ray treatment and hospital admission, according to tariffs differing for members of sick benefit clubs and for other patients. The poor may be treated free of charge. In cases of malignant tumors in the poor, however, the municipal treasury pays the charges — in compliance with the Social Acts — without this being considered poor-relief. In the hospital department the charges differ for ward-bed, 2-bed room and private room.

In Denmark, the combating of cancer is a national movement. It is the charity of the Danish people that has provided the means for the therapeutic measures, and it is through contributions from a very large part of the population of Denmark that it has been possible to erect the new Radium Station of Copenhagen. A great and meritorious work has been carried out by the men who have taken the initiative and have been in charge of its realization. The Danish physicians — and in particular the Danish radiologists — have every reason to be thankful for the working conditions afforded them. Now the work is taken up in the new Radium Station. Through this we hope we shall be able, in return for the economical sacrifices of the people, to bring it recovery of a steadily increasing number of cancer patients.

SUMMARY

In Copenhagen, a new and enlarged Radium Station has been erected in connection with the Finsen Institute. Brief mention is made of its past history, its purpose and its arrangements and organization.

ZUSAMMENFASSUNG

In Kopenhagen ist in Verbindung mit dem Finsen-Institut eine neue und vergrösserte Radiumstation errichtet worden. Verf. berichtet kurz über ihre Vorgeschichte, ihre Ziele sowie über ihre Anlegung und Organisation.

RÉSUMÉ

Un service nouveau et étendu de radium a été crée à Copenhague, en liaison avec l'Institut Finsen. L'auteur donne un bref historique, ainsi qu'un exposé des buts et de l'organisation de ce service.

FROM THE RADIOLOGICAL DEPARTMENT OF THE MALMÖ GENERAL HOSPITAL.
CHIEF: D. B. CARLSTEN, M. D.

SOME EXPERIMENTS IN RECTAL PYELOGRAPHY[1]

by

Knut Wolke

(Tabulæ XLIX—LI)

The production of uroselectan by BINZ and RÄTH and its introduction and testing in clinical medicine by von LICHTENBERG and SWICK in 1929 have presented roentgenology with a new method of investigation — intravenous pyelography. It should however be mentioned that LICHTWITZ (Altona) and HRYNTSCHACK (Vienna) were working, independently of and simultaneously with BINZ and RÄTH, with selectan derivatives and their separation from the body.

At the German Radiological Congress in the spring of 1930 one of the subjects under discussion was intravenous pyelography and von LICHTENBERG then gave an account of his experiences of more than a hundred cases of intravenous pyelography. By degrees an extensive literature has been published on the subject of intravenous pyelography with uroselectan. In addition to the researchers mentioned above attention may be called to the following: BRAASCH, DRACHTER, FREUDENTHAL and LUNÖE, GISSEL, HELLSTRÖM, HUTTER, HYMAN, JACHES, KIELLEUTHNER, KRETSCHMER, ORTH and STOFFEL, PALUGYAY, SGALITZER, VIETHEN, WOLLESEN and others.

These investigators have injected intravenously 100 ccm. of a 40 % uroselectan solution and then made exposures 5—10—30 minutes or more after the injection.

At the Radiological Congress mentioned above a report was read by BRONNER (Cologne) on his results and experiences with a new contrast medium manufactured by I. G. Farbenindustrie — *Abrodil*. This drug goes under the name of Skiadon in the American and English literature. This preparation is at present used quite as much as uroselectan. Others who have employed this new medium are BECKER, KÖHLER, OCHSNER

[1] Submitted for publication Sept. 17th, 1931.

and WISHARD, WOYTEK, ZIEGLER and others. Abrodil is more advantageous than uroselectan on account of its being more easily dissolved and contains a higher percentage of iodine. It contains 52 % iodine as against 42 % in uroselectan, and for this reason it gives a denser shadow and can be used in smaller quantities than uroselectan. It is said also that it gives fewer injurious common effects and is quite harmless when injected outside the vein.

Intravenous injection of uroselectan is not altogether free from disadvantages. In a certain small percentage of cases the patients suffer unpleasantness in some form or other, a sense of warmth and a feeling of thirst, flushing of the skin, cramp in the vessels, headache, urticaria, urinary strains etc. In paravenous infiltration of uroselectan patients have got necroses and abscesses. Thus, certain injurious effects sometimes occur and even when they do not occur a puncture of the vein is for many a disagreeable act. Sometimes an intravenous injection is not possible owing to the lack of a suitable vein. This is often true of infants. One might then try an injection into sinus longitudinalis, but certain pediatrists very strongly advise against such a procedure. As a matter of fact it does not always turn out successfully, which we experienced in one case at this hospital where excretion pyelography would have been well. Tests in rectal pyelography had not yet been commenced and therefore the patient was not pyelographed before being operated. The operation revealed that the child had a large hydronephrotic kidney owing to ureteral atresia with a dilated ureter above the stenosis. It would certainly have been useful for the operating surgeon to have been aware of this before the operation had been performed.

Another disadvantage that might be cited is that the medium has to be prepared immediately before each injection. The salt has to be solved in re-distilled water and sterilised over a water-bath or in an autoclave for 20 minutes. Abrodil requires only boiling for 20 minutes. After being allowed to cool to body temperature it is slowly injected in the space of 10 to 15 minutes. Hence, a procedure requiring a certain amount of time under the supervision of the physician and nurses.

It would be simpler and more agreeable for the patient if the contrast medium could be administered per os or introduced into the rectum for resorption and roentgenograms taken at a certain time later. In other words, if the medium could be administered orally or per rectum.

Both uroselectan and abrodil are resorbed poorly in the ventricle and on entering the bowels the contrast media obscure the kidneys. ZIEGLER and KÖHLER, working with oral introduction of contrast media, obtained the best results with a water solution of 10 grams of sodium iodide and 10 grams of urea. Four hours after the introduction of this compound and after half an hour's compression of the ureters they obtained a compressed

filling of the renal pelves. However, they have not continued their experiments with this solution, and in fact it does not commend itself to us to give patients 10 grams of sodium iodide at once.

If it were possible to procure a medium that could be resorbed exclusively in the ventricle and thus did not enter the bowels we should have much greater prospects of finding a feasible method for oral application.

As regards rectal application this method is not recommended by von LICHTENBERG, KIELLEUTHNER and others. On the other hand ZIEGLER and KÖHLER have succeeded in getting some good results by this method. Exposures quite equal in intensity to those made after intravenous injection have been obtained. The fundamental condition of success is, according to these investigators, compression of the ureters, and their technique is briefly the following: Two hours before the examination the patient is given an enema. By means of a tube introduced above the sphincter a water solution of 20 to 25 grams of abrodil in 50 ccm. of water, or 40 grams of uroselectan in 100 ccm. of water, mixed with 10 to 15 drops of tinct. opii is gently injected, the patient being in a sitting posture. Half an hour later a specially constructed compressorium is fixed on the abdomen over the ureters on a level with the sacroiliac joints and after 20 minutes a first exposure is made. Exposures are then made at short intervals. If no filling of the renal pelves has been obtained an hour after the abrodil enema the remaining solution is flushed out of the rectum.

This method has been tested by WOYTEK of Breslau and he says that he has obtained good pictures, but they were inferior in intensity to those obtained by the intravenous method. Further, the minimum quantity he was obliged to use was 30 grams.

KÖHLER, ZIEGLER and WOYTEK, as well as the Americans OCHSNER and WISHARD, state that the contrast medium owing to antiperistalsis in the colon ascends to flexura lienalis, thus obscuring the left kidney in a few cases. KÖHLER and WOYTEK try to prevent this ascent by administering the enema with the patient in a sitting or half-sitting posture.

In a paper on the relative position of nutritive enemas in the colon LOSSEN (Frankfort) points out that if one wants solutions to remain only in the rectum one should employ as small a quantity as possible. To obtain the best resorption, that is chiefly through columnae rectales and plexus haemorrhoidales, it is necessary to have the contrast solution in the rectum. Another reason for preventing the medium ascending is to avoid a shadow over the left kidney.

How can this be achieved? By baking the required quantity of contrast medium into suppositories of convenient size it is possible to diminish the quantity of the substance to be injected into the rectum and in this way (according to LOSSEN) prevent its ascending. At the same time

we should obtain an easy way of administering the contrast medium. If we then choose a constituent for the suppositories that would make the compound thicker than a water solution and then administer them to the patient in a sitting posture the ascending would be prevented still further.

ZIEGLER and KÖHLER in their enemas used a dose of from 20 to 25 grams of abrodil. As the substance is fairly expensive it would be better to try with their minimum quantity.

In answer to an inquiry as to whether it would be possible to mix this quantity into four suppositories the representative of I. G. Farbenindustrie supplied the following recipe:

Rec.

Abrodil	2 grams
Gelatini pulv.	2 »
Aq. dest.	0.50 »
Glycerini	0.80 »

The preparation presented a number of difficulties but the Fläkta Örn Laboratories of this city succeeded in manufacturing the suppositories, their size being 12 by 40 millimetres.

Suppositories containing an equal amount of abrodil with oleum cacao as binding substance were considerably larger in size and thus not so suitable. In fact it might be presumed that fat as a constituent, as it is not resorbed in the colon, would form an unresorbable covering round the salt particles and thus prevent their resorption.

The required quantity and consistency for rectal application appeared to have been obtained in suppositories with the above-named composition. If KÖHLER and other workers could introduce abrodil into the rectum in such a strong concentration as 40 % without any irritating effects there was every reason to believe that the suppositories would not irritate the bowels. Apart from the small glycerine quantity they contained no irritants.

Already in the first test with four suppositories it was shown, first, that the substance was resorbed in a sufficient quantity to give a shadow — an hour and a half after the introduction of the suppositories a faint shadow could be seen on the bladder film, second, that the patient tolerated the suppositories without any discomfort and third, that the contrast medium kept exclusively to the rectum. Thus, there was every reason to continue along the path hit upon. In all, 37 cases have been examined up to date; 29 suspected of kidney complaints and 8 who, from all appearances, had healthy kidneys but were being nursed at the hospital for other ailments.

The *technique* that has hitherto proved to be the best and which has been employed, with some variations, in all the cases is the following:

The patient is prepared as in a usual kidney examination with one or two days' purgation. In accordance with the memorandum to the various wards the patients are purged two days in succession with a different aperient each day and on the evening before the examination are given an enema. On account of previous experiences of their inefficacy no gas-binding substances have been prescribed. The key-stone of the preparation is the enema the patient gets on the morning of the examination an hour or two before the suppositories are inserted. On the day before the examination the patients are allowed only light fare, preferably mash or cream soup containing the least possible amount of stool-forming substances. The last twelve hours before the examination they are not allowed to drink. The purpose of this is to improve the possibilities of resorption and the excretion. This course was adopted on account of our experience with one of the first cases examined. This patient had by mistake lived on »dry fare» the day before the examination and had thus consumed no liquid during the preceding 18 hours. The excretion pyelography of this patient turned out much better than in the preceding four cases. As no other plausible explanation could be found for this improvement other than the dryness of the patient in question it was decided to introduce a restriction of liquid into the scheme of preparation and we are under the impression that the results obtained since have been better. No control tests without restriction of liquid have as yet been made but they will of course be carried out in the near future. In the literature we read that Palugyay, the Austrian, obtained a better parenchymal shadow in intravenous pyelography when the patient was satiated with water than when he was thirsty, but on the other hand he obtained the best shadow of the renal pelvis when the patient was thirsty. Thus, the same experience with regard to the shadow of the renal pelvis in a state of thirst as was met with in the material at this hospital.

Thus, the patients come to the examination rather deficient in water. As thirst is attended by decreased diuresis it might be brought into question as to whether the excretion will be sufficient, for the intensity of the shadow and the filling of the renal pelves are not only dependent on the iodine concentration in the urine but also on the amount of urine excreted in the unit of time. (GISSEL.)

In order to ascertain if possible whether an increased diuresis would give better results the following experiments were made. Seven patients out of fourteen, all of whom were examined, broadly speaking, in conformity with the technique described above, were given 300 to 400 ccm. of water while the compression was being applied. The other seven were

examined without being supplied with any water. The idea was that the water would produce an increase in the diuresis and in that way create more favourable conditions for the filling of the renal pelves. No differences occurred either in the time for the best filling or in its degree and intensity. The cases with good fillings are divided equally among both groups. Whether diuretics can contribute to better fillings or not is a question that should of course be investigated.

The Roentgen Examination: Two hours after an enema in the morning an ordinary roentgen examination is made of the kidneys and the bladder so as to obtain an idea of the size and form of the renal shadows and of the concretion in the urinary apparatus or elsewhere. Then four suppositories, containing together 20 grams of abrodil, are introduced into the rectum, after which the patient is made to sit up. Forty-five minutes to one hour later a survey film of the kidney and bladder region is taken, as one frequently gets an incipient filling of the renal pelves or contrast in the bladder as a sign that the contrast medium is being excreted. In that case compression is applied above the ureters on a level with the sacroiliac joints. A common compression ball 18 centimetres in diameter has proved to be quite satisfactory. The ball is pressed down by means of the band fitted on most modern examination tables, care being taken only that it is in a symmetrical position and presses equally on both ureters.

If the renal pelves have not commenced to fill at this exposure or no contrast is seen in the bladder the compression is delayed for another 10, 15 or 30 minutes. As a rule compression can be applied an hour or an hour and twenty minutes after the introduction of the suppositories. After a compression of 15 to 45 minutes a good filling of the renal pelves is obtained in normally functioning kidneys. On the average the time required in the examinations made was 25 minutes.

If both sides fail to fill the compression must be continued — patients can stand an hour without any inconvenience — and the pressure increased if necessary. If neither of the renal pelves is filled two and a half hours after the insertion of the abrodil and after at least one hour's compression the examination should be concluded and the contrast medium flushed out with an ordinary water enema.

If one side fails to fill the compressor (the ball) should first be transferred to the non-filled side and films are taken 15, 20 and 30 minutes after, when the examination is concluded.

The longest period required to obtain good roentgenograms was two hours and thirty minutes after the introduction of the suppositories, while the shortest period was one hour. The average period was one hour and 40 minutes. Thus, if the roentgen examination proper is commenced 45 minutes after the insertion of the suppositories the patient will be on the examination table for about an hour.

The longest period for compression was one hour and the shortest 5 minutes.

Schematically summarised the technique of examination is as follows: The patient is prepared, broadly speaking, in the same manner as for an ordinary renal examination and is not allowed to drink for twelve hours prior to the examination. Two hours after the patient has been given an ordinary enema a usual renal X-ray examination is performed, after which four suppositories, each containing five grams of abrodil, are introduced into the rectum. Forty-five minutes later a survey film is taken, and fifteen minutes later another survey film. One hour and fifteen minutes after the abrodil has been introduced into the rectum a compression ball is fixed over both ureters. Pyelograms are then taken about every ten minutes for an hour's time provided such a long period of compression is necessary. If no filling has been obtained by this time the examination is concluded with a flushing enema.

Let us now review the 37 cases examined with regard to the position of the contrast medium in the bowels, the contingent discomforts of the patients, the technical results of the examinations, the significance of the compression and the patient's weight.

Seven of the thirty-seven cases were examined with a smaller dose than 20 grams of abrodil. These seven cases are therefore treated separately further on and the following review thus refers to only thirty cases.

If we look for the location of the contrast compound in the colon in the 30 cases under review it will be seen that an opinion can be expressed of only twenty-eight of them, inasmuch as two patients were unable to retain the suppositories for more than 15 and 20 minutes respectively. All the others, who retained the suppositories for at least an hour, can be considered. In seven of these cases the contrast compound had reached flexura lienalis, while in the others it had remained in the rectum, colon sigmoideum and the lower part of colon descendens. In fifteen out of the latter twenty-one it was found exclusively in the rectum. In none of the seven cases in which the medium had reached flexura lienalis did it obscure the kidney. The outlines of the kidney appeared even plainer in these patients owing to the fact that the contrast medium in the colon had slided, as it were, along the rounded kidney and had taken up a lateral position in the colon. (See figures 1 and 3.)

How did the patients react to the four suppositories? Eighteen tolerated the suppositories without the least discomfort. Eight had strainings during the first ten minutes or in a lesser degree in the course of the examination, but they were not so severe as to compel the breaking off of the examination. In four cases the examination had to be discontinued after fifteen minutes for an hour's time on account of severe tenesmus.

One of these four patients was an extremely neurolabile person bordering on psychosis. The other three patients had been subjected a few days prior to the examination to various examinations that had been preceded by purgation, such as roentgenograms of the kidneys, roentgenograms of the bowels, cystoscopy, etc. All of them had taken aperients from three to four days before the rectal application of abrodil and their bowels were evidently in a state of excessive irritation.

None of the other patients had been subjected to such protracted purgations. In more than half of the cases the first examination undergone was the rectal pyelography.

From what has been said I think the conclusion can be drawn that rectal pyelography should not be performed if there is any suspicion that the patient's bowels are irritated. The examination should be arranged in such a manner that the rectal pyelography is made either at the same time as the usual renal examination or a few days later. Other examinations should be carried out after the rectal pyelography.

If the results are examined from a technical point of view, that is, the degree and intensity of the filling, without regard to whether one or both renal pelves were filled we then have the following:

a) Good filling of both or one renal pelvis	23 cases
b) Less good filling	4 »
c) No filling	3 »
Total	30 cases

Example on normal pyelrogams are fig. 1—4.

These figures refer to all cases examined, even the first cases examined before various improvements in the technique had been introduced.

In *group c* we have the two cases mentioned above that could not retain the suppositories longer .than 15 and 20 minutes respectively owing to tenesmus.

The third case in group c was a big, powerful man weighing a hundred kilos. He retained the contrast medium without the slightest difficulty. After two and a half hours, including an hour's compression, only a very slight filling of the ureters was discernible. None of the other patients came up to this weight, and the failure may be ascribed to insufficient quantity of contrast medium in proportion to the patient's physique. A contributary cause might be poor compression owing to the powerful abdominal muscles of the patient. I shall recur later to the significance of the weight of the body and of compression in rectal pyelography.

In group b we find two cases, who, owing to tenesmus, could not retain the contrast suppositories for more than an hour, which is rather a short time for satisfactory resorption. The third case refers to a patient nursed in the medical department under the diagnosis Polyarthritis sub-

acuta + nephritis chronica. On some occasion a few years ago he had suffered from hematuria and therefore excretion pyelography was performed in order to ascertain, if possible, whether he was affected with any other renal complaint in addition to nephritis.

It was not until three and a half hours had passed since the introduction of abrodil per rectum that curiously shaped, faint contrast-shadows became visible in the regions of the renal pelves. This slow and peculiar excretion, which could not be ascribed to defective resorption, bad compression, heavy weight or similar factors, was explained as being due to impaired renal function caused by the nephritis. A control with retrograde pyelography made three months later, when the clinical picture was still the same, showed more intense shadows but the same curious shape of the renal pelves as with rectal pyelography. The diagnosis was now made of polycystic disease of the kidneys. If our experience of the method had been wider it is possible that this diagnosis might have been made already on the pyelograms obtained with rectal pyelography. Perhaps, the nephritis also acted upon the filling as regards its density.

With regard to the fourth case this was the first of the experimental series. The main cause of the poor filling was undoubtedly the absence of compression, inasmuch as there was a certain amount of filling.

We shall now pass on to say a few words with regard to the importance of compression. As pyelograms were made of all the patients examined first without, and then with, compression, it has been possible to obtain some idea of the significance of compression in pyelography. The opinion formed is that compression is one of the fundamental factors of success in rectal pyelography. It is true that the renal pelvis is filled even without compression, but in a very unsatisfactory manner. For instance, calyces minores is not as a rule filled without compression. The ureter too is filled more completely after compression. The shadow of the renal pelvis will be more intense with compression than without it and the kidney appears more definitely. If the compression is relaxed when the renal pelves are filled and an exposure is made half a minute or a minute later one also gets the lower part of the ureters filled.

No filling of the large canals which Viethen described in one instance, has occurred for certain.

With regard to the compression I beg to refer the reader to Fig. 5—8: 5. Taken after 15 minutes' compression. 6. After 25 minutes' compression. 7. Taken at the same time as the compression was relaxed. 8. Taken 5 minutes later. These pictures speak distinctly in favour of compression.

In another case a clear and beautiful filling was obtained of the right renal pelvis but not of the left. The lumbar part of the left ureter was however filled. From this one may presume that the left kidney also

excreted but for some reason or other there was no filling of the renal pelvis. Although there were no misgivings with regard to the left kidney — the patient had complained of pain over the right kidney — a cystoscope and an ordinary pyelograph of the left renal pelvis were made. Clear urine was obtained from the left ureter and the pelvis was filled without any noteworthy conditions. In view of the fact that normal urine was secreted and no morphological change in the renal pelvis could be discerned by direct pyelography the explanation of the defective filling must be sought in the insufficiency of the compression. The patient was as a matter of fact rather stout and therefore difficult to compress.

This observation has made me take special care when applying the compression to make sure that neither of the ureters was insufficiently compressed. In the event of only one of the renal pelves being filled one should first see that ureter of the unfilled pelvis is specially compressed. I have observed in several patients that if a renal pelvis does not become filled after the usual compression period it will do so quickly if special compression is applied to the ureter.

It is only when this procedure does not bring about the filling of the renal pelvis that we are justified in suspecting the kidney.

The employment of compression is by no means generally accepted. It is not used by the majority of those who have occupied themselves with intravenous pyelography (von LICHTENBERG, LICHTWITZ, WOYTEK, KENNETH and HERITAGE, the Englishmen, OCHSNER and WISHARD, the Americans, and others).

That ureteral compression is of importance for filling has been emphasised from obstetrical quarters (SCHUMACHER of Giessen). In intravenous pyelography of gravidae good filling of both renal pelves and ureters was obtained in 100 % of the cases, which SCHUMACHER considers was entirely due to the uterine pressure on the ureters. Other obstetricians, such as von SCHUBERT of Berlin and LEIXL of Munich, hold the opinion that, in addition to compression, tonic changes in the sympathetic nerve system with their subsequent paralyses of the smooth musculation of the ureters and the renal pelves have a favourable effect on the filling.

ZIEGLER, KÖHLER, HAENISH, HYMAN, VIETHEN and others advocate the use of compression as necessary if good results are to be obtained.

The opponents of the use of compression look upon it as unphysiological. Indeed, in this respect we have to acknowledge that they are right. But then the majority of researchers agree that secretion pyelography as a functional test is a crude method. For the study of the function of the kidneys there are finer methods: water test, determination of nonprotein nitrogen, colour test, etc. The greatest value of excretion pyelography is the picture it presents of the morphological conditions of the two kidneys and renal pelves.

If the best pictures are obtained after compression then compression cannot be abandoned because it is unphysiological, inasmuch as we have, as already mentioned, better means at our disposal for the study of the physiological. If pyelograms are made, as has been the case here, both with compression and without then we do not deprive ourselves of the possibility of getting a certain idea of the function of the kidneys.

In order to form some idea as to the significance of weight a comparison has been made between the filling results and the weights of the different patients. Information was available of the weight of only 24 patients and these weights were as follows:

18 patients	below	75 kilos	
1 patient	81 »	Good	filling
1 »	82 »	»	»
1 »	88 »	»	»
1 »	90 »	»	»
1 »	90 »	Poor	»
1 »	100 »	No	»

The results of the fillings in the 18 cases weighing less than 75 kilos were not studied closely as they are on the whole the same and the slight differences in the fillings may have been caused by other factors than the weight.

The six patients weighing more than 75 kilos are all found among the latter half examined and were therefore subjected to the same technique. For that reason I consider that I am justified in comparing the results of the fillings.

The patient weighing 100 kilos has already been mentioned. One of the 90 kilo patients belongs to group b. — less good filling. As he did not retain the suppositories for more than an hour no opinion can be expressed in his case as to the significance of the weight. The other in spite of his 90 kilos showed a good filling after being given 20 grams of abrodil.

This latter case led to tests being made for the purpose of finding out whether results could be obtained with a smaller quantity of abrodil than 20 grams. As already mentioned, such tests were made in seven cases.

Weight	Quantity of abrodil	Filling result	Abrodil/kilo
48 kilos	15 grams	Very good	0.31
29 kilos (Neuropathic child)	10 »	Test failed	—
51 kilos	15 »	Good	0.29
33 kilos	10 »	Good	0.30
63 kilos	15 »	Less good	0.23
50 kilos	15 »	Very good	0.30
50 kilos (Nephritis)	15 »	Less good	0.30

In dosing abrodil for children in intravenous pyelography BRONNER suggests 0.3 gram per kilo of the body weight. If this dosage formula were also applied in rectal pyelography a patient weighing 50 kilos would require a dose of 15 grams and a patient weighing 80 kilos a dose of 24 grams. Should the patient exceed 85 kilos in weight it would therefore be wise to increase the dosage to 25 grams, in spite of the fact that in our tests good result were obtained with 20 grams in a patient weighing 88 kilos. (Fig. 4), and one weighing 90 kilos.

The test made have thus proved that, provided the dose of contrast medium is sufficient and the patient is able to retain the suppositories, pictures of the renal pelves, quite equal to those obtained by intravenous pyelography, can easily be procured by means of the technique described here.

The most suitable dosage, expressed in grams, is obtained by multiplying the weight of the body by 0.3

With regard to *the indications for rectal pyelography* they are on the whole the same as those in intravenous pyelography, and these are, according to the opinion of most workers, the following:

1) Cases where cystoscopy and ureteral catheretization is impossible.
   a) Mechanical obstacles in the urethra or ureter: strictures, calculi, pressure from the outside, for instance, gravide uterus, myom or enlarged prostata.
   b) Advanced bladder affections or supersensitive patients.
   c) Children.
   d) Cases in which the general state of health is too poor.
2) Cases in which there is an element of danger in making pyelographic examination, as in advanced hemorrhages or in an infected bladder where there is a risk of conveying the bacteria to a healthy kidney.
3) As a functional test and a general survey of the urinary apparatus.

Special indications are supplemented for rectal pyelography, viz.

1) Cases where it is not possible to puncture the vein.
2) Cases with contra-indications against intravenous pyelography:
   a) Thyrotoxicoses.
   b) Pronounced renal insufficiency.
   c) Advanced tbc.

   In rectal pyelography the blood is not flooded with contrast medium to the same extent as in intravenous injection.
3) In policlinic examinations on account of the simplicity of the method and in cases where the patient refuses vein puncture.

There are practically speaking no *contra-indications* in rectal pyelography. If the contrast medium is flushed out after two or two and a half hours in those cases where injury might be caused nothing will happen. By that time a great part of the medium has probably not been resorbed.

Difficulty in retaining the suppositories has occurred in a little more than 10 % of the cases. This figure can certainly be reduced if nervous patients are given a vagus-arresting substance, for instance, bella donna, and further if the examination is not performed while the bowels are in a state of severe irritation.

It is possible that the small quantity of glycerine in the suppositories irritates the rectum. In order to eliminate this possible course of irritation a few tests with suppositories without glycerine have lately been made besides the 37 cases mentioned before. I have tried to use partly cacao-suppositories partly suppositories made after the following recipe:

Rec.

Abrodil	5	grams
Extr. Belladonna	0.007	»
Gelatini pulv.	2	»
Aq. dest.	1	»
Glycerini	0.40	»

Up to the present tests have been made in 12 cases, only one of which had some difficulties in retaining the suppositories and the results with regard to the filling were good in all.

It might be assumed that patients affected with hemorrhoids would be troubled by the rectal application. This is not the case, however, provided the suppositories are covered with some kind of lubricant. We had one or two patients with hemorrhoids but they suffered no discomfort when the suppositories had once been got past the sphincter. This is facilitated, as we have already mentioned, by the aid of some lubricant. The most suitable substance for this purpose is one that is readily soluble in water, for instance, a tragacanth solution.

It is not intended here to enter closely into the diagnostic value and possibilities of excretion pyelography. Our material is much too small to allow of any generic expressions of opinion and we must refer the reader with regard to this matter to the large works on pyelography by VON LICHTENBERG, HUTTER and SGALITZER, PALUGYAY and others. We will only mention that the films of the 23 cases characterised as »good filling» are quite comparable to those obtained in intravenous pyelography.

In conclusion a brief description of some cases will be given, cases which may show the results obtained in rectal pyelography as it is performed at the General Hospital at Malmö.

Case 1. Mrs A. S. 46 years of age. Weight 60 kilos. There was nothing of any interest in the old anamnesis. A week before being admitted into the hospital the patient had been troubled by constant strainings and the urine had been turbid. No ague until the last three days before being admitted. Temperature above 40 degrees C. Besides, pains in the left side of the abdomen. Temperature and pain continued but strainings and temperature diminished. Temperature when admitted 38.4 C.

The patient felt pain over the left kidney in bimanual palpation. Urine macroscopically clear. Abundant white blood-corpuscles and coli-bacteria in the sediment. In an *ordinary renal X-ray examination* on 22/5 a shadow of a rounded soft part was seen above the location of the right renal pelvis, the etiology of which could not be determined. Below the kidney parallel with the outlines of the psoas there was a row of calcium shadows, certainly caused by glandular sclerosis. There were no definite concrement shadows inside the urinary apparatus. *Rectal pyelography* on 27/5: »Excretion in the usual manner from both kidneys without any delay. Filling on both sides, when it appeared that the right kidney was furnished with bifid pelves with separate ureters for a length of at least 10 centimetres. (Fig. 9). *Cystoscopy* on the 28/5. »The bladder without defect. Orifice of right ureter without fault. Simple orifice. Two catheters introduced, »*Retrograde pyelography* of the right kidney on the 28/5: The same picture, (Fig. 10), as in the rectal pyelogram.

Thus, we have in this case a patient suffering from pyelitis with bifid pelves on the right side. The case is interesting for comparison between the pyelograms obtained in rectal pyelography and those obtained in ordinary pyelography.

Case 2. Mrs K. B. 72 years old. Weight 57 kilos. Since July 1930 the patient had had pains in the lower part of the abdomen, felt an increased need of urination and pain in urinating. No blood in the urine. The patient had been operated in January for prolapse of the uterus. The trouble continued however. Severe pains in the abdomen. The patient became thinner and thinner. On admittance to the hospital a tumour was palpated on the left side of the abdomen.

Rectal pyelography (Fig. 11) was performed as the first examination on the 8/6. »Right kidney of usual size and form. Left kidney lumpy, especially the lower pole. The kidney shadow measured 9 × 14 cm. Both renal pelves were filled without any delay. The left pelvis had a curious shape, especially the lower part, where the filling was incomplete. The distance to the contour of the lower pole of the kidney is 9 cm.»

Cystoscopy on the 15/6. »Mucous membrane of the bladder was very wrinkled, somewhat red and bleeding slightly. Orifice of right ureter without fault. The right ureter was catheterised slightly. At the position of the left ureteral orifice there was a pronounced trabeculated region. The ureteral orifice was not visible and therefore could not be catheterised.»

New *cystoscope* on the 18/6. »After an injection of methylene blue intramuscularly the ureteral orifice on the left side was discovered. The catheter could only be introduced 1 cm.

Here is a case in which secretion pyelography gives more definite information than cystoscopy and ureteral catheterisation. The latter

showed nothing else but that the left ureter could not be catheterised. Excretion pyelography on the other hand showed that the kidney was enlarged and the renal pelvis deformed.

The finding of the roentgenogram suggests the presence of a tumour and a tumour was palpated on the left side of the abdomen in the seat of the kidney. The patient has not been operated and it has therefore not been possible to verify the diagnosis.

Case 3. A policlinic patient. Mrs G. F., the wife of a medical man, 25 years of age. Weight 60 kilos. This patient had for the last two years suffered from pyelitis. The husband, who is a bacteriologist, had never been able to find anything but colibacteria in the bladder urine. The patient had been treated with urine antiseptics, coli-vaccine, etc. She had been *cystoscoped* at another hospital in the autumn of 1930 but nothing noteworthy had been observed in the ureteral orifices. There was nothing wrong with the left ureter. The right ureter could not be catheterised. *Renal roentgenogram* made on the same occasion showed no defect.

Rectal pyelography on the 12/6 ,1931. »Right kidney appears to be decreased. The margins however appear indistinctly. The left renal shadow is larger than usual and across the upper half is seen a curved shadow, the etiology of which is uncertain, (enlarged spleen). After abrodil had been introduced per rectum the contrast medium was excreted in the usual manner and without any delay on either side. The right renal pelvis is situated however abnormally close to the spine and becomes filled in a very remarkable manner except the calyces, in addition to which the adjoining ureter, to the length of one decimetre, is pathologically distended (as thick as a lead pencil). The left renal pelvis is of the usual size and shape. No visible concrementnt shadows within the urinary apparatus. (Fig. 12).

Cystoscopy was performed the same day at another hospital: »Close to the orifice of the right ureter, which was oedematous and impossible to catheterise, there are some granulating ulcers like tbc in appearance. No defect in the ureteral orifice and ureter.» *Guinea pig test* of bladder urine was negative.

Cystoscope on the 12/7. (Dr. LÖFBERG). »Mucous membrane a little reddened but no visible ulcers. Orifice of right ureter obliterated. Urine from left ureter in usual drop sequence. Nothing microscopically. Right ureter felt like a soft string.

This case has not yet been investigated sufficiently but is included in order to show the singular picture of the renal pelvis on the right side.

Case 4. K. J. A sailor, 29 years of age. Nothing particularly of interest in the old anamnesis. Had had painful attacks in the upper left part of the abdomen of and on since November 1930. At the same time urinary strainings, fever and ague. On a few occasions the urine had been bloody. The attacks had lasted a day or so and then abated, only a dull ache remaining. He was admitted into the hospital after such an attack. On admittance there was a soreness over the left kidney and pusbodies and colibacteria were found in the urine. No tbc. bacilli. *Renal roentgenogram* on the 30/4: »No positive changes in the kidneys. No visible concrement shadows inside the urinary apparatus.» *Cystoscope* the 11/5: The mucous membrane of the bladder rounded, reddened, hairy like velvet. No specially pronounced redness around either of the ureteral orifices. The ureters were slightly catheterised. Normal urine.» *Rectal pyelography* the 15/5: »Beautiful

filling of the right renal pelvis and ureter while the left side failed to fill in the usual manner.» *Cystoscope* on the 19/5 shows an almost normal mucous membrane of the bladder. Ureters without defect. Clear urine from both in normal drop sequence. Usual *direct pyelography* of the left kidney shows a bag-shaped renal pelvis 4 cm. × 8 cm. in size without the calyces. Diagnosis was made of intermittent hydronephrosis and the patient *was operated on* the 21/5. From the report of the operation: »The greatly decreased kidney is situated in the usual place and is firmly attached to the surroundings. This applies especially to the pelvis, which is distended to the size of a mandarin orange. The ureter is narrow and of normal appearance. At the place where it enters the renal pelvis it is crossed at the back by an aberrant, taut renal vessel of a fairly large calibre. This has probably brought pressure to bear on the ureter — — — ».

The preparation: The renal pelvis as large as a mandarin orange, rather thick-walled, filled with turbid urine. The parenchyma limited to at most one-third of the normal. *Microscopic examination* showed powerful atrophy with great destruction of glomeruli, fat infiltration in the tubuli and severe interstitial increase of connective tissue.

A patient presents an anamnesis, which mostly suggests nephrolithiasis attacks. The renal roentgenogram exhibits no concrement shadows. Cystoscopy shows nothing especially noteworthy. Nor does ureteral catheterisation. Clear urine from both kidneys. Rectal pyelography shows that the left kidney does not excrete the contrast medium in the usual manner. It should be examined further and a usual pyelography discloses a bag-shaped, extended renal pelvis, which is verified at the operation. The patient had had an intermitting hydronephrosis caused by an aberrant vessel.

That no filling occurred in the left side was due partly to the reduced renal parenchyma and partly to the big bag, in which the small amount of contrast medium was diluted incapable of giving a satisfactory shadow.

The usefulness of rectal pyelography in this case was that, in spite of the fact that ureteral catheterisation had shown normal conditions, it indicated plainly that one of the kidneys was damaged.

SUMMARY

In a short introduction the author reviews the disadvantages which, in his opinion, is inherent in the intravenous method of administering contrast media in secretion pyelography, and then goes on to give a survey of the methods of application described hitherto.

A detailed description is then given of the preliminary tests made at the Malmö General Hospital by means of rectal introduction of abrodil in the form of suppositories. The tests, amounting to 50 in number, are criticised from various points of view.

The writer expresses the opinion that by employing the technique described it is possible to perform satisfactory excretion pyelographies very easily in all cases

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

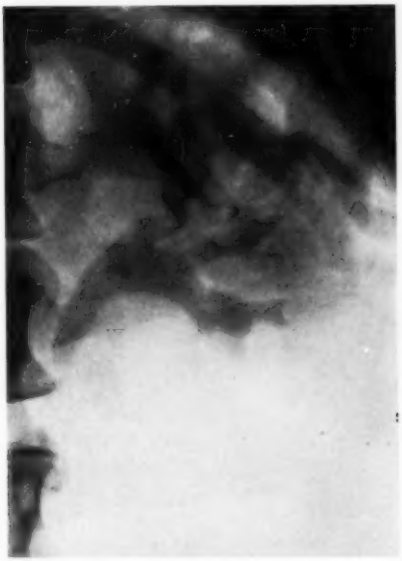

Fig. 5.

Fig. 6.

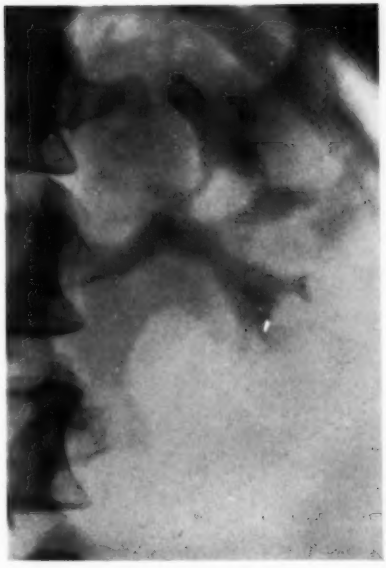

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

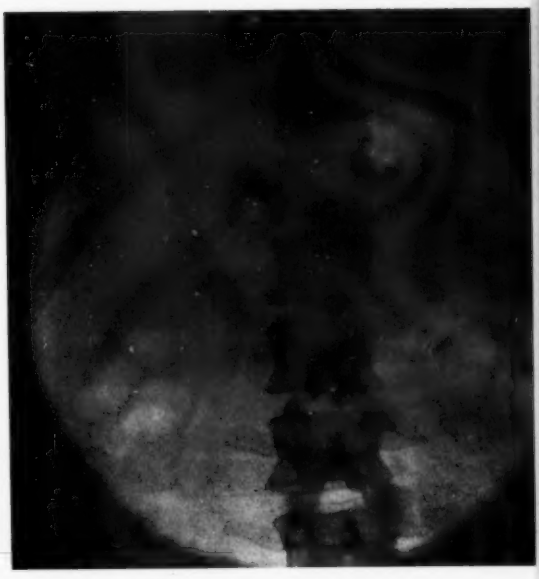

Fig. 12.

where the patients are to retain the contrast medium in the rectum. The tests made were successful in nearly 90 % of the cases. By exercising due care this figure might surely be increased considerably.

A short section is devoted to the indications and contra-indications in secretion pyelography in general and rectal pyelography in particular.

In conclusion a few cases are mentioned illustrating the results attained.

ZUSAMMENFASSUNG

In einer kurzen Einleitung bespricht Verf. die Nachteile, die seiner Meinung nach der intravenösen Einverleibungsmethode von Kontrastmitteln für die Sekretionspyelographie anhaften, und gibt ferner einen Überblick über die bisher beschriebenen Applikationsmethoden.

Sodann bringt er eine detaillierte Beschreibung der am Allgemeinen Krankenhause in Malmö gemachten präliminären Versuche mittels rektaler Einführung von Abrodil in Form von Suppositorien und erörtert die Versuche, 50 an der Zahl, von verschiedenen Gesichtspunkten.

Nach der Ansicht des Verf. ist es bei Anwendung der beschriebenen Technik in allen Fällen, wo die Patienten imstande sind, das Kontrastmittel im Rektum zurückzuhalten, mit Leichtigkeit möglich, zufriedenstellende Exkretions-Pyelographien zu machen. Die Versuche waren bei nahezu 90 % der Fälle erfolgreich. Bei Beachtung der richtigen Sorgfalt kann diese Ziffer sicherlich noch beträchtlich erhöht werden.

Ein kurzer Abschnitt ist den Indikationen und Kontraindikationen der Sekretionspyelographie im allgemeinen und der Rektalpyelographie im besonderen gewidmet.

Zum Schluss werden einige Fälle erwähnt, welche die erhaltenen Resultate illustrieren.

RÉSUMÉ

Dans une brève introduction, l'auteur énumère les inconvénients que présente, à son avis, la méthode intraveineuse d'administration de milieux de contraste dans la pyélographie de sécrétion, et donne un aperçu général des méthodes d'applications décrites jusqu'ici.

Il donne ensuite une description détaillée des essais préliminaires faits à l'Hôpital Général de Malmö par l'application rectale d'abrodil sous forme de suppositoires. Ces essais, qui sont au nombre d'une cinquantaine, sont l'objet d'un examen critique à divers points de vue.

L'auteur exprime l'opinion que, par l'usage de la technique décrite, il est possible, dans tous les cas où le malade est susceptible de garder dans le rectum le milieu de contraste, d'obtenir facilement des pyélographies d'excrétion satisfaisantes. Les essais effectués ont donné des résultats favorables dans près de 90 % des cas. En observant les précautions nécessaires, cette méthode est certainement appelée à se développer notablement.

Un court chapitre est consacré aux indications et aux contre-indications des pyélographies de sécrétion en général et plus particulièrement de la pyélographie rectale.

Comme conclusion, l'auteur rend compte d'un certain nombre de cas illustrant, les résultats atteints.

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GUIDO HOLZKNECHT

In Memoriam

Aus Wien ist die traurige Nachricht eingegangen, dass GUIDO HOLZKNECHT am 30. Oktober 1931 verschieden ist.

Er wurde am 3. Dez. 1872 in Wien geboren. Nach gründlichen medizinischen Studien in Wien, Strassburg und Königsberg war HOLZ-

KNECHT fünf Jahre lang an der Klinik NOTHNAGELS in Wien tätig und führte dort seine ersten grundlegenden Arbeiten auf dem Gebiete der Röntgendiagnostik aus. Im Jahre 1904 erhielt er die Dozentur für medizinische Radiologie an der Universität in Wien und wurde im Jahre 1914 zum ausserordentlichen Professor für dieses Fach ernannt. Bei Erhalt der Dozentur wurde er gleichzeitig zur Leitung des Zentralröntgenlaboratoriums im Wiener Allgemeinen Krankenhause berufen, wo er wirkte, bis Krankheit in diesem Jahre seine Kräfte brach.

HOLZKNECHT war ein Feuergeist, der in Enthusiasmus für die neue Wissenschaft entbrannt war, die ihn fesselte und seine ganze Persönlichkeit in ihren Bann gebracht hatte. Er verstand auch wie nur wenige, seine Umgebung zu gemeinsamem Interesse und gemeinsamem Schaffen mit sich fortzureissen. Er selbst war ein unermüdlicher Arbeiter. Energisch tätig, um der Röntgenwissenschaft an der Universität und in der praktischen Heilkunde den Weg zu bahnen, wurde er mitunter durch sein lebhaftes Temperament zu Attacken verleitet, die weit in der Welt widerhallten. Er hatte indes in Wien gegen einen Widerstand und ein mangelhaftes Verständnis für die Lebensbedingungen der Radiologie zu kämpfen, die es gut erklärlich machen, dass sein Lebenswerk im Zeichen des Kampfes verlief.

HOLZKNECHTS Stärke lag in seinem Ideenreichtum und seiner technischen Phantasie, die es ihm gestattete, die Eigenart des neuen physikalischen Hilfsmittels, das Röntgen der Heilkunst geschenkt hatte, rasch zu erfassen und es praktisch verwendbar zu machen. Sein Mut und sein Drang, neue und schwierige Aufgaben in Angriff zu nehmen, machten ihn zu einer schöpferischen Kraft bei der ersten Bebauung der reichen, aber gefahrvollen Gefilde, die sich der Medizin durch das Röntgenlicht eröffnet hatten. Er hatte auch einen ausserordentlichen Überblick über die Literatur der Röntgenologie und deren Grenzgebiete und einen scharfen Blick für die neuen Möglichkeiten, die sich zu dieser Zeit für seine Wissenschaft boten.

HOLZKNECHTS erste röntgenologische Publikation stammt aus dem Jahre 1899 und behandelt die Röntgenbefunde bei Bronchostenose. Der Höhepunkt seiner Entwicklung fällt in das erste Dezennium unseres Jahrhunderts. Seine Tätigkeit war durchwegs bahnbrechender Natur. Damals galt es noch, die ersten Grundlagen für die Röntgentechnik zu schaffen, erst die Hauptzüge des verwickelten Schattenspieles der Röntgenbilder zu deuten und die ersten Röntgenbefunde zu einer systematisch aufkeimenden Wissenschaft zu ordnen und zu sichten.

HOLTZKNECHT war in fast allen Gebieten der Röntgendiagnostik und Röntgentherapie mit unerschöpflichem Eifer tätig. Er war auch schon im Jahre 1903 mit der Radiumtherapie beschäftigt. Über zweihundertfünfzig Arbeiten streute er mit freigiebiger Hand aus und inspirierte eine

Schar von Mitarbeitern zu zahlreichen wissenschaftlichen Werken. Die Mitwelt sah mit Erstaunen den Reichtum der Quelle, die aus dem Laboratorium des jungen HOLZKNECHT entsprungen war.

Man kann ohne Übertreibung sagen, dass HOLZKNECHT und die Wiener Schule in der ersten Zeit dieses Jahrhunderts in der Entwicklung der Röntgenologie die führende Stellung einnahmen.

Drei grosse Werke werden für alle Zeiten den Namen GUIDO HOLZKNECHTS in der Geschichte der Medizin bewahren. Er arbeitete die Durchleuchtung zu einer praktisch anwendbaren Methode aus. Er führte die erste wissenschaftliche Dosierungsmethode in der Röntgentherapie ein und zeigte ihre Verwendbarkeit in der Praxis. Er gründete an seiner Röntgenabteilung in Wien eine Ausbildungsanstalt in Röntgenologie, die der ganzen Welt zu einer Zeit offen stand, in der noch keine Universität dieser Wissenschaft ihre Pforten geöffnet hatte.

Vor HOLZKNECHT war das Durchleuchtungsbild des Mediastinums eine undifferentiierte Silhouette, und der Hilusschatten ein diffuser Begriff. Durch seine grosse Arbeit im Jahre 1901 »Die röntgenologische Diagnostik der Erkrankungen der Brusteingeweide» wurde die Röntgenanatomie der Brustorgane auf grundlegende Weise klargelegt, wenngleich die Forschung späterer Zeiten die Kenntnis der Röntgenbilder der Brustorgane immer mehr vervollständigte. Am bekanntesten von HOLZKNECHTS röntgendiagnostischen Arbeiten ist indes seine Untersuchung vom Jahre 1906 über die Form, Lage und Grösse des normalen Magens, und die Arbeit vom Jahre 1912 über das normale Röntgenbild des Duodenums. Was HOLZKNECHTS klarstellende Arbeit hier bedeutete, und welche Schwierigkeiten zu überwinden waren, das wird vielleicht am besten illustriert, wenn ich daran erinnere, dass bei der Diskussion in einer Sitzung der Nordischen Chirurgischen Gesellschaft im Jahre 1911 von erfahrenen und geschickten Klinikern die stärksten Zweifel darüber ausgesprochen wurden, ob das Röntgenbild des Magens wirklich der inneren Kontur des normalen Magens entspreche.

Vor HOLZKNECHTS Erfindung des Chromoradiometers im Jahre 1902 war es wegen Mangels an einem annähernd exakten Dosimeter nicht möglich, eine wissenschaftlich kontrollierte Röntgenbehandlung auszubilden. Der Chromoradiometer gründet sich auf Beobachtungen des Physikers GOLDSTEIN, dass gewisse Salze bei Beleuchtung mit Röntgenlicht durch den Verlust des Kristallwassers die Farbe verändern, und dass diese Farbenveränderung unter Passierung einer gewissen Farbenskala vorsichgeht, in der jede Farbennuance einer gewissen Quantität absorbierten Röntgenlichts entspricht. So geht das gelbgrüne Salz Bariumplatinzyanur bei Absorption von Röntgenlicht über verschiedene Nuancen von gelb in braun über. Gestützt auf die Beobachtung, dass auch die biologische Wirkung der Röntgenbestrahlung auf die Haut der Quantität absor-

bierten Röntgenlichtes proportional zu sein schien, konstruierte HOLZKNECHT auf empirischem Wege eine Farbenskala, in der die Farbe einer mit einer gewissen Quantität Röntgenlicht beleuchteten Schicht von Bariumplatinzyanur einer gewissen Hautreaktion entsprach, und stellte eine biologische Einheit für das Röntgenlicht auf, die nach ihm den Namen »Eine Holzknecht-Einheit» oder »Ein H.» trägt. HOLZKNECHTS Chromoradiometer ist nun durch vollkommenere Instrumente ersetzt, beherrschte aber in verschiedenen Ausführungen fast durch zwei Dezennien die Dosimetrie bei der Röntgentherapie. Mit Hilfe seines Chromoradiometers führte HOLZKNECHT die sogen. expeditive Röntgenbehandlungsmethode durch, mit der man in einer oder einigen wenigen Sitzungen mit genau gemessenen Strahlenmengen ohne Gefahr für den Patienten dieselbe Heilwirkung zustandebrachte, für die man früher, wo man sich ohne genaue Messung vorwärts tastete, 10, 50, ja über hundert Bestrahlungen hat ausführen müssen.

Ausserdem dass HOLZKNECHT durch seinen Chromoradiometer der Röntgentherapie eine allgemeinen Stütze schenkte, beteiligte er sich auch auf mehreren Gebieten der Röntgentherapie an der Ausarbeitung der speziellen Behandlungstechnik.

Schon im Jahre 1903 gab HOLZKNECHT eine Arbeit über die Radiologie als selbständigen Zweig der medinizischen Wissenschaften heraus, und bis die Krankheit in den letzten Jahren seine Kräfte schwächte, kämpfte er in einer grossen Anzahl von Schriften dafür, der Radiologie den Platz zu schaffen, der ihr in der praktischen Krankenbehandlung und an den medizinischen Fakultäten gebührt. Wenngleich spät, so durfte er es doch noch erleben, dass die Röntgenologie an den Universitäten Österreichs als Unterrichtsgegenstand für die Studenten eingeführt wurde, wenn auch nur als nichtobligater.

Seine grösste Bedeutung als Lehrer hatte HOLZKNECHT indes durch den Unterricht, den er — neben dem Universitätsunterricht — für Ärzte abhielt, die von allen Enden der Welt zu ihm strömten, um sich im Röntgenfach auszubilden, oder sich röntgenologische Kenntnisse in einem gewissen Spezialzweig der Medizin zu verschaffen. Mit grosser Sorgfalt orientierte er sich über die Kenntnisse und Wünsche jedes einzelnen und veranstaltete Kurse, die von ihm selbst oder von seinen Assistenten mit Berücksichtigung der Bedürfnisse der Schüler abgehalten wurden. Er hatte dieselbe Unterrichtsmethode, wie sie im schwedischen Anatomieunterricht seit der Zeit ROLAND MARTINS gebräuchlich ist, mit Analyse der Fälle vor den Schülern in Form von Fragen und Antworten. Ich selbst habe im Jahre 1907 seinen Unterricht genossen und sowohl in Bezug auf die Röntgenologie als auch auf den Unterricht Lehren empfangen, die für meine Entwicklung als Radiologe von entscheidender Bedeutung waren.

HOLZKNECHTS früher bahnbrechender Erfolg in der Röntgendiagnostik wie in der Röntgentherapie beruhte zum grossen Teil auf seiner Fähigkeit, rasch das wesentliche zu sehen und die sich häufenden Beobachtungen zu systematisieren. Seine grösste Schwäche war eine bisweilen übertriebene Schematisierung und Generalisierung.

Der Weltkrieg, der Österreich so schwer traf, wirkte auch hemmend auf die wissenschaftliche Arbeit HOLZKNECHTS. Während des Krieges war er als Leiter und Organisator des militärärztlichen Röntgendienstes rastlos wirksam. Im letzten Dezennium richtete HOLZKNECHT sein Interesse hauptsächlich auf die Organisation der Röntgenarbeit und den Unterricht in Röntgenologie. Seine Kräfte waren indes durch Schäden untergraben, die er sich in der Jugend bei der Röntgenarbeit zugezogen hatte. Die vielen Durchleuchtungen ohne jeden oder ohne zureichenden Schutz riefen eine schwere und schmerzhafte chronische Dermatitis an seinen Händen hervor, und in den Röntgenwunden trat Karzinom auf. Die letzten Jahre waren für HOLZKNECHT ein ununterbrochenes Martyrium. Nach zahlreichen Operationen an beiden Händen musste schliesslich im Juli dieses Jahres sein rechter Arm amputiert werden. Es kamen innere Metastasen hinzu, und jetzt ist er von seinem Leiden erlöst.

HOLZKNECHT war das grosse Glück vergönnt, neuen Gebieten der Medizin den Boden zu bereiten und den Grundstein zu einem Bauwerk zu legen, das durch viele Generationen seinem Namen Glanz verleihen wird. Er selbst ging an den unbekannten Gefahren zugrunde, die den Pionier in diesen neuen Wissenschaftsgebieten bedrohten. Mit Heldenmut ertrug er seine Verletzungen, von Liebe zu seiner Wissenschaft beseelt. Gross war das Opfer, das er auf ihrem Altar bringen musste, aber gering gegen das Glück, das sein Lebenswerk ihm selbst schenkte, und gegen den Nutzen, den es für seine Mitmenschen brachte.

Die jetzt heranwachsende Generation von Radiologen kann sich keine Vorstellung davon machen, was HOLZKNECHTS Tätigkeit bedeutete in einer Zeit, in der wir noch nicht daran gewohnt waren, mit »Röntgenaugen» zu sehen. Für uns, die wir am Morgen dieses Jahrhunderts jung waren, stand er wie Aladdin, dessen Lampe unseren Augen ganz neue Gebiete eröffnete, ein freigebiger Aladdin, strahlend vom Glücke des Entdeckens und des Spendens.

Jetzt, da die Röntgenstrahlen ein unentbehrliches Hilfsmittel in der Hand der Medizin geworden sind, und ihr Gebrauch uns so selbstverständlich erscheint, sollen wir nicht vergessen, dass diese Gabe nicht vollendet vom Himmel gefallen ist. Sie ist zum grossen Teil durch Mühe und Aufopferung einzelner Radiologen erobert worden. Die Radiologen der ganzen Welt schulden dem Andenken HOLZKNECHTS unvergänglichen Dank für die lange Zeit, da er uns den Unterricht bot, den die Universitäten hätten erteilen sollen. Jetzt steht sein Lehrstuhl

verlassen, und der Strahlenkranz des Märtyrers hat den Schein der Lampe des jungen Aladdin ersetzt.

Die Augen der ganzen radiologischen Welt sind jetzt auf die medizinische Fakultät der Wiener Universität gerichtet in der Hoffnung, dass die Radiologie an der Universität HOLZKNECHTS eine Stellung erhält, wie sie seines grossen Lebenswerks würdig ist.

Gösta Forssell

ERRATUM

Dans le résumé en français du travail du D:r LEOPOLD FREUND *Sur les méthodes d'irradiation dans le cancer*, paru dans le fascicule 4, il s'est glissé dans le 4e alinéa une erreur de traduction. La phrase en question doit être modifiée de la façon suivante: »On appliquera, en séances fréquentes, des doses faibles et prolongées, dont aucune ne sera inférieure à la valeur limite d'activité thérapeutique, et se suivant à intervalles rapprochés, aux néoplasmes qui ne présentent qu'une sensibilité modérée aux irradiations, peu développés en profondeur et n'augmentant que d'une façon progressive.»

NORDISK FORENING FOR MEDICINSK RADIOLOGI

7:DE MØDE I REYKJAVIK 1932

Nordisk Forening for medicinsk Radiologi afholder sit 7de møde i *Reykjavik* i juli 1932. Anmeldelse om foredrag bedes sendt til undertegnede. Arrangement om fælles rejse fra og til København vil blive truffet, men deltagerne kan ogsaa komme til Reykjavik via Bergen, Edinburgh, Hull eller Hamburg. Der er planlagt interessante turistrejser paa Island i tilslutning til kongressen. Udførligere program for kongressen og de i tilslutning til denne trufne arrangementer vil senere framkomme i den medicinske presse i de skandinaviske lande. Anmeldelse om deltagelse i mødet bedes sendt til CHR. I. BAASTRUP, generalsekretær i Nordisk Forening for medicinsk Radiologi. St. Kongensgade 68, *København*.